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A System that Supports Learners' Strategic Thinking for Solving Highschool Mathematics Problems

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Abstract: In high-school mathematics, learners sometimes cannot solve problems well even if they remember formulas. At other times, learners cannot solve similar problems well even if they see a sample answer of the original problem. These cases indicate that *mathematical knowledge*, such as knowledge of the formulas and definitions in high school math textbooks, is insufficient to solve problems. Past studies have shown that it is important to plan which formula should be used in problem solving. The knowledge necessary to determine which formula should be used in problem-solving is called *knowledge of the problem-solving strategy*. In the past researchers on educational support systems, there is no established method for mathematics education support systems to construct a problem-solving process with the knowledge of the problem-solving like a human doing. In this study, we analyze problem-solving process in which learners use *the knowledge of problem-solving strategy* from specific examples. After that, we construct a system with problem-solving ability using *the knowledge of the problem-solving strategy*. Our system can also verbalize problem-solving processes constructed by itself and let learners read the generated commentary. We conducted a preliminary experiment comparing the commentary with sample answers in usual reference books. In this preliminary experiment, we evaluated the correct answer rate of similar questions and the acquisition rate of *the knowledge of problem-solving strategy*. As a result, subjects reading the commentary by the system mark better correct answer rate of similar problems, and they can reproduce *the knowledge of problem-solving strategy* better than ones reading reference books.

Keywords: problem-solving, high school mathematics, knowledge of problem-solving strategy

1. Introduction

In high school mathematics, sometimes learners cannot solve problems well even if they remember formulas. At other times, even if they see the sample answer of the original problem, they cannot solve a similar problem well. These cases indicate that *mathematical knowledge*, such as formulas and definitions in high school math textbooks, is not enough to solve problems. Then, what kind of abilities and knowledge other than *mathematical knowledge* is necessary? There are researchers who say that it requires various abilities. According to Garderen (2006), spatial visualization ability is important for solving math problems. Based on the level of understanding capabilities of each student, Ramdhani (2017) reports that students who have a high, moderate, or low self-efficacy master the indicators of mathematical understanding. Daniel and Michèle (2007) report that a wide variety of abilities such as reading comprehension and information processing is required for solving math problems. Tarzimah and Thamby (2010) report that various skills such as number fact, arithmetic, information, language, and visual–spatial skills are necessary in solving mathematics problems. They also report that the most important of these skills is the information skill, which is the expertise in connecting information to a concept, operation, and experience or transferring information and transforming problems into a mathematical sentence.

As in these studies, problem solving in mathematics requires a variety of abilities. These abilities affect the learner's thinking, but it is difficult to directly observe it. Therefore, we focused on the learner's problem-solving process. The problem-solving process is either written in answers or implicit. We thought to analyze not only the part written in the answer but also the implicit part. Polya's model, Mayer's model, and Kintsch's model are well-known examples of the models of the mathematical problem-solving process. Polya (1962) proposed that the mathematical problem-solving process consists of four stages: “understanding the problem,” “devising a plan,” “carrying out the plan,” and “looking back.” Kintsch and Greeno (1985) proposed that the mathematical problemsolving process can be classified into both the “problem understanding process” and “problem-solving process.” Mayer (1992) proposed that the “problem understanding process” consists of “conversion” and “integration,” and the “problem-solving process” consists of “planning” and “execution.” The focus of each of these models is to understand the problem and plan for problem-solving. Chinnappan and Lawson (1996) report that the students in the experimental group who are encouraged to plan and learn have higher problem-solving ability than those in the control group who only learned using examples. From these previous studies, not only mathematical knowledge but also *the knowledge of the problem-solving strategy*, such as planning what formulas to use and when and how to use them, are important for problem solving.

There are LEAP, MOLE, and SEEK2 as educational systems that focus on the problemsolving process. Mitchell (1985) analyzed expert problem-solving processes at LEAP and LEAP learns the used knowledge as new rules. Politakis (1984) compared the problem-solving process of a system to that of an expert at MOLE and fixed a bug. Ginsberg (1985) automated some of the bug fixes of MOLE at SEEK2. These systems are excellent for acquiring knowledge, but not for evaluating learners' answers. Brown (1978) proposed an educational system that can point out why the answer is wrong by modeling the learner's error as a bug model. This system is good at pointing out errors in learners' answers, but it is not suitable for explaining why the correct answer used a particular formula.

There is no established method for mathematics educational systems to construct a problemsolving process with *the knowledge of the problem-solving* like a human doing. We thought that if the system could solve the problem using *the knowledge of the problem-solving strategy*, the system can point out specifically which part of the learner's answer is wrong and why. It can also explain why the correct answer used a particular formula. Therefore, we analyze problem-solving process in which learners use *the knowledge of problem-solving strategy* from specific examples. In this paper, we construct the system with the ability to solve problems by itself using *the knowledge of the problemsolving strategy*. In addition, our system can also verbalize problem-solving processes constructed by itself and let learners read the generated commentary. We also conducted a simple preliminary experiment to measure the learning effect when learners read the commentary output by the system. As a result, it was suggested that learners who read the commentary output by the system readily improve their ability to solve similar problems and acquire the knowledge of the problem-solving strategies better than those who read the commentary in usual reference books.

2. Basic discussion

2.1 Problem domain

In this paper, we select trigonometric functions in high school mathematics as a problem domain. That is because the field of trigonometric functions requires *the knowledge of the problem-solving strategy*. We made a case study regarding how learners build a problem-solving process based on 30 trigonometric exercises from a high school math reference book. From the problem-solving process, we extracted the *knowledge of the problem-solving strategy* and *mathematical knowledge*.

2.2 problem-solving process

As a result of the examination, we find that the problem-solving process is configured as shown in Figure 1. Each step in this problem-solving process employs a single strategy. Particularly, each step is comprised of the following flow. In this paper, we refer to expressions that are set as the initial conditions of the problem and the goal of the problem or expressions that are inferred through reasoning as "known expressions."

<1> *Known expression* and manipulation are written. (2.2.1 “manipulation”)
<2> Conditions for manipulation are written. (2.2.2 “Condition of applying the strategy”)
<3> Benefits of manipulation are written. (2.2.3 “benefits of manipulation”)

There are two types of methods for the problem-solving step, forward reasoning and backward reasoning. Forward reasoning is the right arrow in Figure 1, and backward reasoning is the left arrow in Figure 1. The *known expression* obtained by forward reasoning is called “*forward known expression.*” The *known expression* obtained by backward reasoning is called “*backward known expression.*”

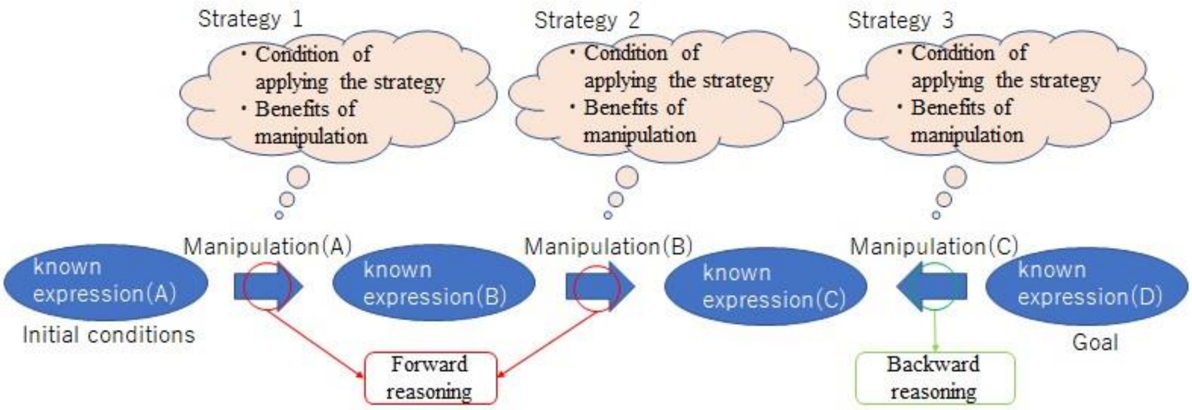

Figure 1. Problem-solving process

2.2.1 Manipulation

In Figure 1, manipulation is the conversion of a formula that occurs when any *knowledge of a problem-solving strategy* is applied. *Manipulation* serves as a bridge between the *mathematical knowledge* and *problem-solving strategy knowledge*. For example, assume that there is a strategy that is based on a *mathematical knowledge* “double-angle formula (Sin[2*x] = 2*Cos[x]*Sin[x]).” Then, the *manipulation* of the strategy is “applying Sin[2*x] = 2*Cos[x]*Sin[x] to the target formula.”

2.2.2 Condition of applying the strategy

The “condition of applying the strategy” in Figure 1 is a condition that determines whether a certain strategy is available or not. For example, to use the double angle formula (Sin[2x] = 2Cos[x]Sin[x]), "Sin [2*x]" must exist in the formula of the *known expression*. To rationalize the denominator, a root must exist in the denominator of the *known expression*. In the case of forward reasoning, the “condition of applying the strategy” is a condition targeting initial conditions and the *known expression of forward*. In the case of backward reasoning, the “condition of applying the strategy” is a condition targeting the goal and the *known expression of backward*.

2.2.3 Benefits of manipulation

The “benefits of manipulation” (BoM) show what kind of benefits can be obtained by actually applying a strategy. The BoM is used to determine how applying a strategy helps to solve problemsolving. In the BoM, there is no distinction between forward reasoning and backward reasoning.

The BoM can be classified into (A) “benefits of a single strategy” and (B) “benefits of multiple strategies.”

(A) *benefits of a single strategy*: benefits of a single strategy are benefits that help problem-solving. *Benefits of a single strategy* are provided when applying a single strategy. For example, using the double-angle formula gives the benefits of “declination coefficient can be 1.”

(B) *benefits of multiple strategies*: *benefits of multiple strategies* are provided when predicting the next strategy to apply. The *benefits of multiple strategies* also apply multiple strategies. The *benefits of multiple strategies* are the same as the *benefits of a single strategy*, and applying multiple strategies can provide benefits that help problem-solving. Additionally, *the benefits of multiple strategies* also have the benefits of looking to a next step, such as “Formula 2 can be transformed into a form to which

Strategy 2 can be applied," as shown in Figure 2. For example, when a form "Sin[x] + Cos[x]" exists in a formula of a *known expression*, the formula can be converted to the form "Sin[x]^2 + 2*Cos[x]*Sin[x] + Cos[x]^2" by performing the operation of raising both sides to the second power. Hence, you can obtain the benefits of the "formula: Sin[x]^2 + Cos[x]^2 = 1 can be applied."

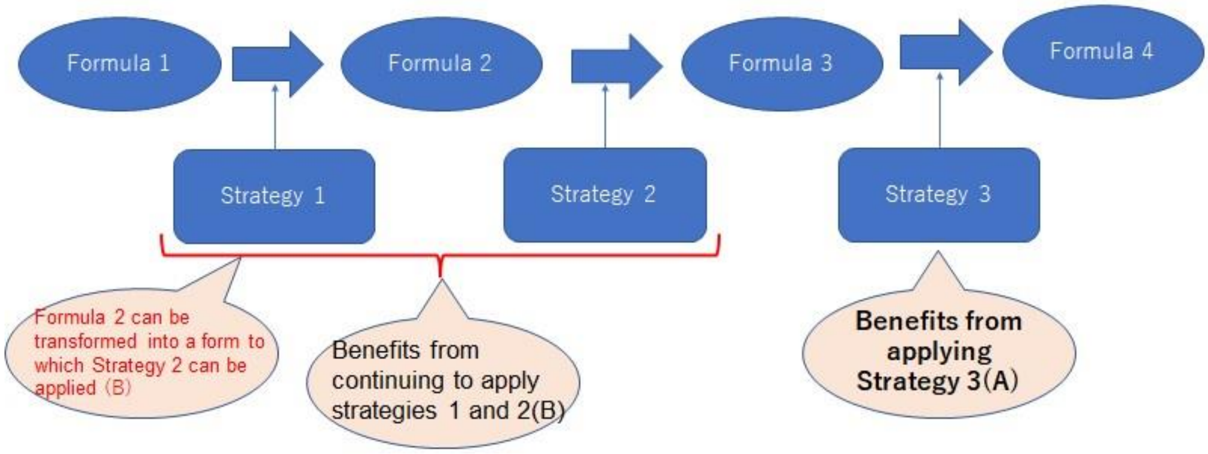

Figure 2. Classification of BoM (A), (B)

Alternatively, the "benefits of manipulation" can be classified into (α), (β), and (γ) from the viewpoint of factors that cause the benefits.

(α) benefits always provided: benefits always provided are benefits that are provided regardless of the form of the *known expression* to which the strategy is applied.

(β) benefits that are provided if conditions are satisfied: *benefits that are provided if the conditions are satisfied* are benefits that are provided when a formula to which the strategy is applied satisfied certain conditions for each benefit.

(γ) benefits that are provided as a result: unlike (α) and (β), *benefits that are provided as a result* are not provided when a specific strategy is applied. *Benefits that are provided as a result* are benefits that are provided when the result is a specific pattern no matter which strategy is applied.

As an example of (α)(β)(γ), consider the case of using the double-angle formula for a formula of the *known expression*. Using the double-angle formula, a benefit of the "declination coefficient can be 1" is provided as (α). If the declination of the *known expression* is [x] except for Sin [2*x], problem solvers can obtain the benefit of the "declination in the formula can be unified" as (β). If the result of the manipulation can be reduced, problem solvers can obtain the benefit of "formulas can be reduced and simplified" as (γ).

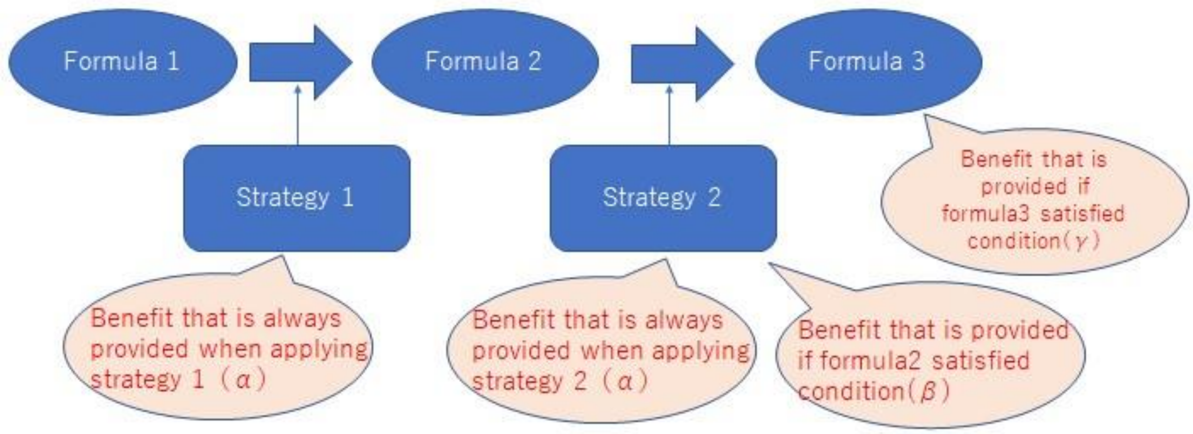

Figure 3. Classification of BoM (α), (β) and (γ)

2.3 Knowledge of problem-solving strategy

As discussed thus far, the problem-solving process has *manipulation*, the *condition of applying the strategy*, and the *benefits of manipulation*, as shown in Figure 1. As a result, the *knowledge of the problem-solving strategy* must include the ability for the *condition of applying the strategy and* *manipulate as a factor*. Additionally, the *benefits of manipulation* must be considered because (γ) *benefits that are provided as a result* are provided with reference only to the result of applying the strategy and are used to guide the overall problem-solving. Therefore, the *knowledge of problemsolving strategy* was then composed of the *manipulation*, *condition of applying the strategy*, and *benefits of manipulation* other than (γ) *benefits that are provided as a result*.

2.4 Problem-solving algorithm

We were able to sort out the flow of the learner's building problem-solving process. Now, we build a problem-solving algorithm that constructs the problem-solving process according to the flow shown in Figure 1. In preparation for building the algorithm, we define the "inference distance." The *inference distance* measures a degree of coincidence between the *forward known expression* and *backward known expression*. The *inference distance* is generally judged by BoM, degree of a formula, number of terms and so on. However, the inference distance is currently judged only by the equality of *the expressions*. When the *inference distance* becomes zero, *forward known expression* and *backward known expression* are the same formula. Then the problem-solving is successful. The flow of the algorithm is as follows:

<1>Ask the learner to enter initial conditions and goals (Save each information as a *known expression*).

<2>Check if each strategy satisfies the *condition of applying the strategy* for the currently declared *known expression*, and then, pick up the strategy. However, if the same strategy was applied to the same information in the past, it does not pick up. If no strategy satisfied the *condition of applying the strategy*, we fail to build a problem-solving process.

<3>Apply all the strategies picked up in <2> to the *known expression* that satisfies the conditions.

<4>Generate the *known expression* based on the result of applying the strategy.

<5>Measure all the inference distances between the forward and backward *known expression* pairs. If the inference distance is zero, the problem-solving process is built successfully. If the inference distance is not zero, return to <2>.

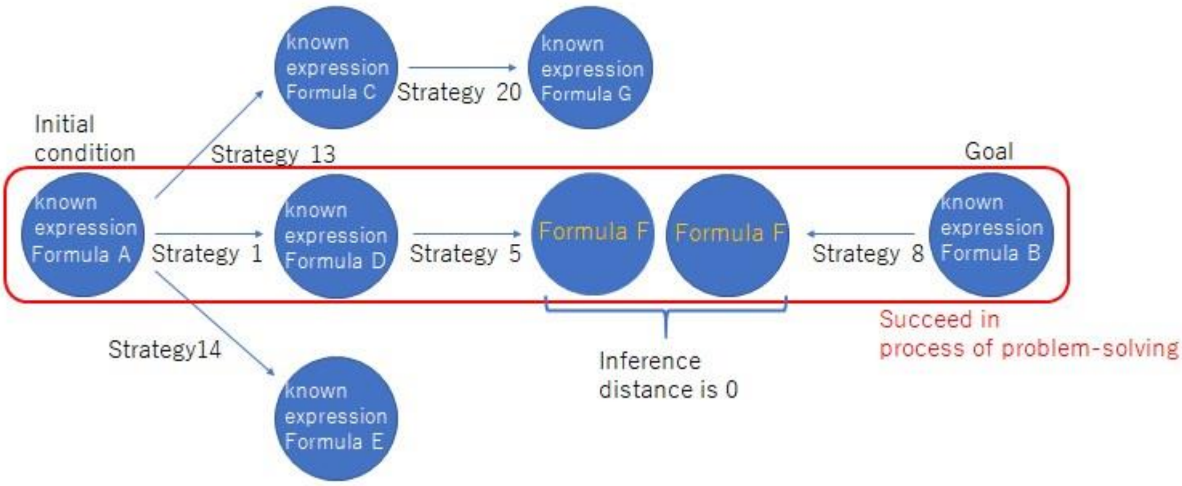

Figure 4. An example of problem-solving process

Figure 4 shows the flow of building a problem-solving process according to the algorithm. In Figure 4, the initial condition is Formula A, and the goal is Formula B. (<1>) The system first looks for a strategy that satisfies the *condition of applying the strategy* for Formula A or Formula B. (<2>) As a result, strategy 13, strategy 14, and strategy 1 apply to Formula A, and strategy 8 applies to Formula B. (<3>) By applying all applicable strategies, the system can obtain new Formulas C, D, and E by forward reasoning and formula F by backward reasoning. (<4>) The system measures all the inference distances between the forward and backward *known expression* pairs. (<5>) As a result, the inference distance is not zero. Thus, the system looks for a strategy that satisfies the *condition of applying the strategy* for Formulas C, D, E, and F again. (<2>) It finds that strategy 20 applies to formula C and strategy 5 applies to Formula D. (<3>) By applying all of these, the system can obtain new Formulas G and F by forward reasoning. (<4>) The system measures all the *inference distances* between the forward and backward *known expression* pairs again. <5> As a result, the *inference distance* between Formula F of the *forward known expression* and formula F of the *backward known expression* is zero. Therefore, the system succeeds in building a problem-solving process.

Through this algorithm, the system attempts to build a process based on exhaustive searches using a strategy that satisfies the *condition of applying the strategy*. This search is not very heuristic. Therefore, the system may not be able to explain to the learner why the strategy was selected from strategies that satisfied the condition. Therefore, the system cannot explain why a strategy was chosen. However, it can explain the benefits of using that strategy. Because each strategy used in the problem-solving process built by the system has BoM. We believe that learners can understand effective strategies for problems and learn guidelines for problem solving.

2.5 Generate a commentary

The system can output a commentary that emphasizes the *knowledge of the problem-solving strategy* (Figure 5). We believe that the learners can become aware of the *knowledge of the problem-solving strategy* by reading the commentary. The commentary is generated by preparing a template and applying the process of problem-solving maintained by the system to it, but the details are omitted in this paper.

In the commentary, each element of *the knowledge of the problem-solving strategy* is shown with emphasis. Step 1 represents the content of one *knowledge of the problem-solving strategy*. In addition, in the output concerning the *benefits of manipulation*, the notation method is changed for each classification of benefits. (α) The benefits always provided, as shown in <1> of Figure 5, can be written as [standard tactics] to learn what guidelines should be applied to the strategy used. (β) The *benefits that are provided if the conditions are satisfied*, as shown in <2> of Figure 5, can be notated as [the benefits of the manipulation in this problem] to indicate the usefulness of the strategy in a particular situation. (γ) The *benefits that are provided as a result* are denoted as [the result of applying the strategy] and can convey to the learner a guideline for the overall problem-solving.

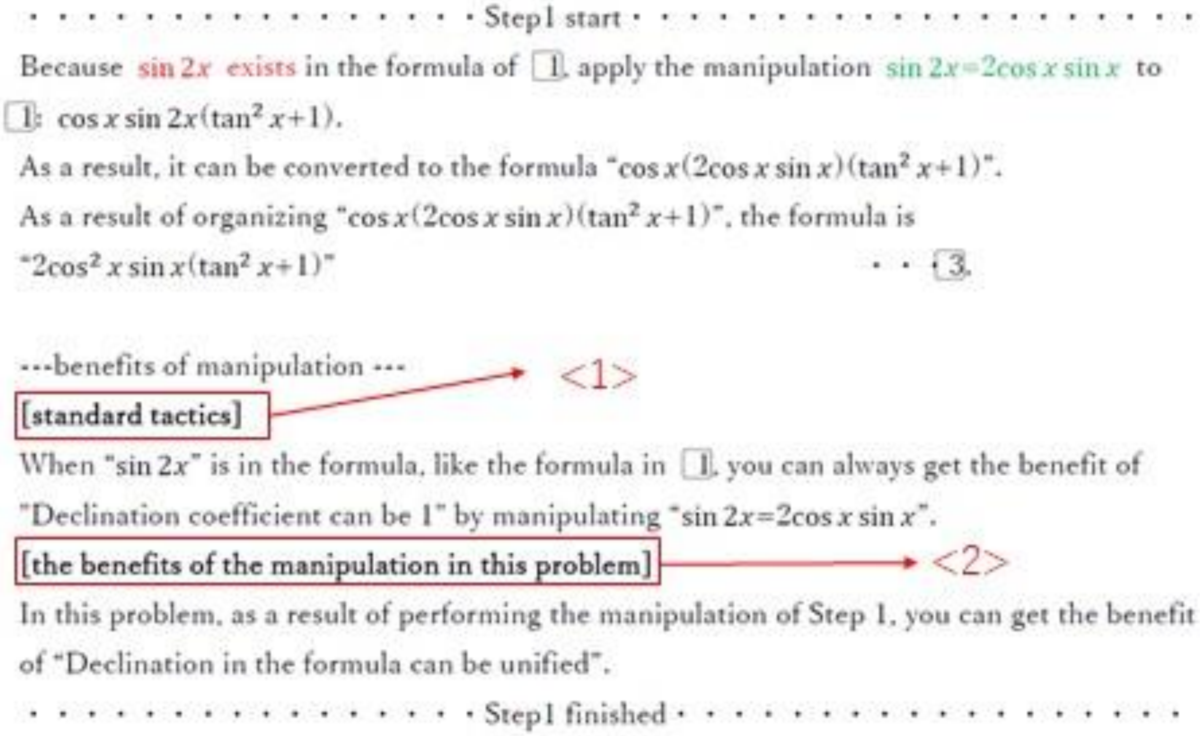

Figure 5. The commentary output by the system

3 Implementation

3.1 System architecture

The system architecture is shown in Figure 6. A learner enters the initial conditions and goals in the system's input/output UI. The system uses the problem solver to build a problem-solving process with the strategy database as a reference. Then, the system uses the commentary generator to generate a commentary.

When the system receives input on the initial conditions and goals of the problem, it outputs the commentary as an HTML file of the constructed problem-solving process. Formulas in the commentary are output by MathML, a markup language. This allows learners to read the formulas, such as fractions and exponents, in a form that is familiar to them and reduces the burden of reading explanations.

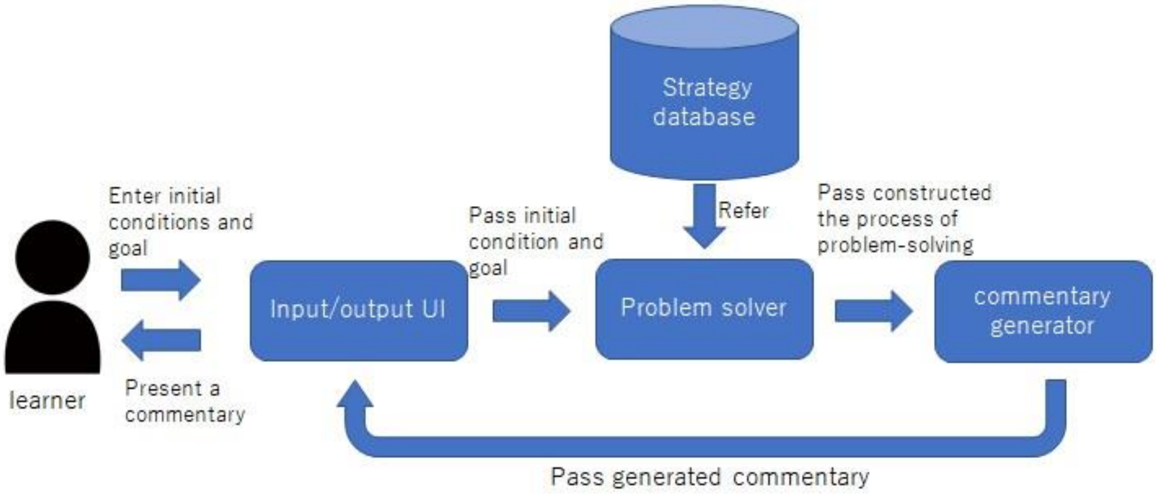

Figure 6. System architecture

3.2 Database of problem-solving strategy

Currently, the system has approximately 30 strategies. The system can build a problem-solving process within the range of the 30 strategies combined. With the current system, the construction of a problem-solving process can cover approximately 60% of the trigonometric proof problems in high school mathematics in a usual reference book sold in Japan.

3.3 Process of mathematical deformation

Mathematical deformation is necessary for the system to apply strategies and organize the information it holds. When the system applies strategies to formulas, such as adding, subtracting, modifying, and applying formulas, it uses Wolfram Research's Mathematica (Wolfram Research 2022). Mathematica is a mathematical deformation processing system. Mathematica is also used to convert the form of a formula to MathML when generating commentary.

4 Preliminary experimental evaluation

An evaluation experiment was conducted to determine if the system would be useful for learners to acquire *the knowledge of the problem-solving strategy* and increased problem-solving ability for similar problems. This experiment is a preliminary experiment conducted with a small number of subjects.

4.1 Experimental hypothesis

The experimental hypothesis of this experiment are as follows:

Hypothesis 1:By reading the commentary output by the system, learners can acquire the *problem- solving strategy knowledge* better than learning without the system.
Hypothesis 2: By reading the commentary output by the system, learners are able to solve similar problems better than learning without the system.
Hypothesis 3: Learners who understands *the knowledge of the problem-solving strategy* are able to solve similar problems better than learners who do not understand the knowledge.

4.2 Method of the experiment

The subjects of this experiment are six university students. Subjects are grouped into Group A and Group B, each of which includes three subjects. Two problems are used in this experiment: Problem 1 and Problem 2. These problems should have the same level of difficulty as much as possible. For that reason, we chose these problems having the same number of steps. We regard these problems as having approximately the same difficulty. At first, an explanation of what is the knowledge of the problem-solving strategy is given to subjects. It explains that *the knowledge of the problem-solving strategy* consists of *manipulation*, the *condition of applying the strategy*, and the BoM with concrete examples, as shown by four slides. Then, the following flow is conducted.

<1> Groups A and B solve Problem 1. Next, Group A reads the commentary generated by the system. Group B reads the commentary in the usual reference book.
<2> Subject writes the *knowledge of the problem-solving strategy* learned in <1>.
<3> Groups A and B solve two similar problems of Problem 1. (Similar problem is the problem in which the same strategy as that of Problem 1 is used.)
<4> Subject writes the knowledge of the problem-solving strategy learned in <3>.

Next, the similar flow as <1> to <4> is executed with Problem 2.
In these steps, the roles of Group A and Group B are interchanged. Specifically, Group A reads the commentary in the reference book, and Group B reads the commentary generated by the system.
Finally, the subjects answer the following questionnaire:
(Q1) Was it possible to be aware of the *knowledge of the problem-solving strategy* by using the system?
(Q2) Did you find it easier to solve similar problems by using the system? (Q3)
Please write your opinion on this system freely.

4.3 Result

The results of the preliminary experimental evaluation are presented in Table 1, Table 2, Table 3, and Figure 7. In Table 1 and Table 3, the subject's answers in step <4> are graded by the following flow:

・If *the condition of applying the strategy* is collected, score plus 1.

・If the *manipulation* is collected, score plus 1

・If the *benefits of manipulation* is collected, score plus 1.

As a result, the answer is graded on a scale of one to three.

Hypothesis 1: As a result, the average score of the knowledge of the problem-solving strategy for subjects who solved the problem reading the commentary of system was 2.67 points, as shown in Table 1. The average score of the knowledge of the problem-solving strategy for subjects who solved the problem with reading the commentary of reference book was 0.75 points, as shown in Table 2. Therefore, subjects can learn knowledge of the problem-solving strategy better if you read the commentary generated by the system. As a result of the questionnaire (Q1), all the subjects answered: "I was very conscious" or "I was a little conscious," as shown in Figure 7. Therefore, the experimental hypothesis 1 was found to be supported.

Hypothesis 2: The correct answer rate of similar problems for subjects reading the commentary of system was 91.6%, as shown in Table 2. The correct answer rate of similar problems for subjects reading the commentary of reference book was 75.0%, as shown in Table 2. Therefore, subjects who read the commentary of system has a higher percentage of correct answers for similar questions than subjects who read the commentary of reference book. As a result of the questionnaire (Q2), 83.3% of the subjects answered, "Thanks to the system, it was very easy to solve similar problems" or "Thanks to the system, it was a little easy to tackle similar problems," as shown in Figure 7. Therefore, the experimental hypothesis 2 was found to be supported.

Hypothesis 3: The correct answer rate of similar problems for the subjects who understand *the knowledge of problem-solving strategy* was 80%, as shown in Table 3. The corrects answer rate for the subjects who did not understand *the knowledge of the problem-solving strategy* was 71%, as shown in Table 3. Therefore, the experimental hypothesis 3 was found to be supported.

Table 1. *Knowledge of problem-solving strategy each group* on the step<4>

	Group A	Group B
Commentary of System	**3.0**	**2.3**
Reference book	**0.8**	**0.7**

Table 2. *Correct answer rate for similar Score in problems in each group on the step<3>*

	Group A	Group B	Average
Commentary of System	**100%**	**83%**	**91.6%**
Reference book	**67%**	**83%**	**75.0%**

Table 3. *Difference of correct answer rate caused by understanding the knowledge of problem-solving strategy*

		Group A	Group B	Total correct answer rate
Subjects who understand the strategy（score in the step <4> is 3）	**Correct answers**	**8**	**0**	**80% (4/5)**
	Incorrect answers	**0**	**2**	
Subjects who don't understand the strategy (score in the step <4> is less than 3)	**Correct answers**	**2**	**8**	**71% (5/7)**
	Incorrect answers	**2**	**2**	

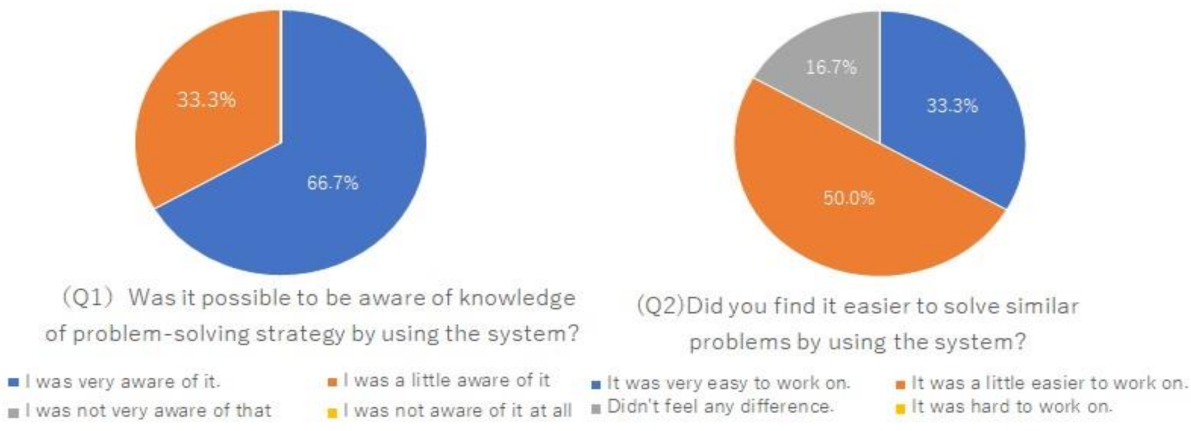

Figure 7. Answers to questionnaire(Q1) and (Q2)

5. Conclusion

In this research, we construct a system with an ability to solve problems by itself using *the knowledge of the problem-solving strategy*. After that, we built a function to verbalize the constructed process and output it as a commentary. Results of the preliminary experimental evaluation proved that the system helps learners acquire *the knowledge of the problem-solving strategy* and their ability to solve similar problems. The system is useful for learners who face mathematics-specific difficulties and can show them how to think about those difficulties. We believe this research can propose one of the useful methods in the educational support system for mathematics.

In the future, the system will be able to evaluate the validity of the answers and provide specific advice for their answers. If it can evaluate the validity of the learner's answer, it will be able to detect alternative answers and provide more flexible learning support. To provide specific advice to the learner's response, it will consider the presence of disadvantages rather than the presence of benefits.

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Enabling Physical- and Concept-Walk in VRbased Open-ended Historical Learning Space

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Abstract: In history study, it is desirable for students to understand the structural connections among people, events, and historical sites, and to experience the appearance, scale, and location of historical sites, rather than merely memorizing them. On the other hand, it is desirable for students to understand the connections between historical facts and to learn through actual experiences such as visiting actual historical sites. This is difficult to achieve in textbooks because of the limited amount of information that can be presented in textbooks. In this study, we propose a learning support system for exploring historical sites, which aims to achieve both immersion and independence of learners by switching between a pseudo-historical site exploration (Physical Walk) and a related term exploration (Concept Walk). We have developed a system that can follow the interests of various learners and provide a subjective and immersive learning experience by switching between a pseudo-historical site exploration (Physical Walk) and a related term exploration (Concept Walk). In this paper, we overview the system, the technical issues we used to overcome, and the results of an initial evaluation experiment of the system. In addition, we mention a more adaptive support planned to implement which generates questions based on the related terms and ontologies.

Keywords: Learning in an Open-ended Space, Virtual Reality, Physical Walk, Concept Walk

1. Introduction

Proactive learning in which students engage in independent learning while maintaining their interests, and deep learning in which students elaborate their ideas by interrelating knowledge are considered important from the perspective of active learning (MEXT, 2021). Considering support for such learning as applied to history learning, which is the target of this study, it is desirable for learners to learn independently according to their own interests, to expand their interests by immersing themselves in the world of history, and to learn by understanding the relationships among people, events, historical sites, and so on (Sulistyo et al., 2020; Bekele, 2019). To support such learning activities, it is essential to encourage learning that involves a sense of space, and learning that involves structurally linking many persons, events, historical sites, etc., but it is not easy to achieve this in a way that can follow the diverse interests of learners. Because of the limited amount of information available in textbooks, it is difficult to understand the appearance and location of historical sites with a spatial and threedimensional sense. It is also not easy to learn many terms and concepts by structurally relating them through one-dimensional explanations in the text.

In this study, we are developing a learning support system for exploring historical sites in an open-ended learning space, combining the exploration of spatial connections (Physical Walk) to explore historical sites and the exploration of semantic connections (Concept Walk) to trace related words and phrases, in order to follow learners' interests and create opportunities for deep active learning by expanding their interests.

This paper describes the learning environment provided to learners. From the internal point of view of the system that realizes this environment, we describe the technical challenges to realize the proposed system as an open learning space and the technical breakthrough to overcome them, and report on pilot evaluation experiments to get a feel if our goal is likely to be achieved.

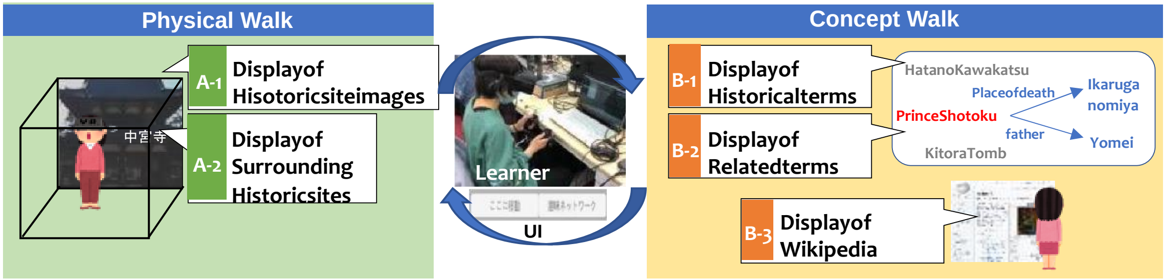

Figure 1. Relationship Between Physical Walk and Concept Walk.

2. Physical Walk and Concept Walk

In order to realize the Physical Walk and Concept Walk, this research utilizes Virtual Reality (VR) technology (Kim & Hall, 2019). By utilizing Virtual Reality (VR) technology, Wikidata Query Service (WDQS)[1], and Google Maps API[2], we will develop an immersive learning support system for exploring historical sites in VR space that enables both Physical Walk and Concept Walk. Figure 1 shows the relationship between Physical Walk and Concept Walk.

Physical Walk: If learners can immerse themselves in a place where they learn history immersively, it is expected to arouse various interests, provoke questions as a learning resource that drives independent learning, and motivate them to explore history. On the other hand, there are not many opportunities to explore actual historical sites. Therefore, we are developing a VR-based support system to realize a pseudo-exploration of historical sites. In this research, we call this "Physical Walk" and realize a mechanism that can recognize the three-dimensional information of historical sites and the positional relationship between groups of historical sites. The goal of this research is to enable learners to observe the scale and atmosphere of historical sites (e.g., Hōryū-ji Temple) and their location in relation to surrounding historical sites (e.g., Chūgū-ji Temple).

Concept Walk: If the system can capture historical sites, people related to them, and historical facts, and visualize and display the connections between them, it will contribute to deep learning by interconnecting knowledge. In this study, we call this activity of exploring related items "Concept Walk." By displaying the paths of related terms representing historical events, people, etc., and allowing the user to move back and forth along the paths, the understanding of semantic connections in multiple directions is facilitated. In addition, by presenting detailed information on the words selected by the learner, we aim to arouse the learner's interest and to promote independent learning driven by this interest.

3. VR-based Support System for Historical Active Learning

We have developed a VR-based historical site exploration and learning support system that combines both Physical Walk and Concept Walk. Figure 2 shows the internal structure and user interface of the developed system. The system uses Wikidata Query Service (WDQS) and Google Street View Static API[3] on Unity. Learners can use the system while wearing an Oculus Rift (Fig. 2(A)).

When the system is launched, the learner selects the region and period of interest on the learning start screen (Fig. 2(B)). Historical terms that match the selected conditions are displayed in the VR space, and the learner can select the term of interest with the controller. The system retrieves the historical terms from WDQS that match the region and period selected by the learner, and places the

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[1] Wikidata Query Service: https://query.wikidata.org/

[2] Google Maps API: https://developers.google.com/maps

[3] Google Maps Platform: Street View Static API: https://developers.google.com/maps/documentation/streetview/overview

obtained data in the VR space (Fig. 2(C)). If the learner selects a historical site, he or she can explore and learn in both Physical Walk and Concept Walk modes, and if the learner selects any other terms,

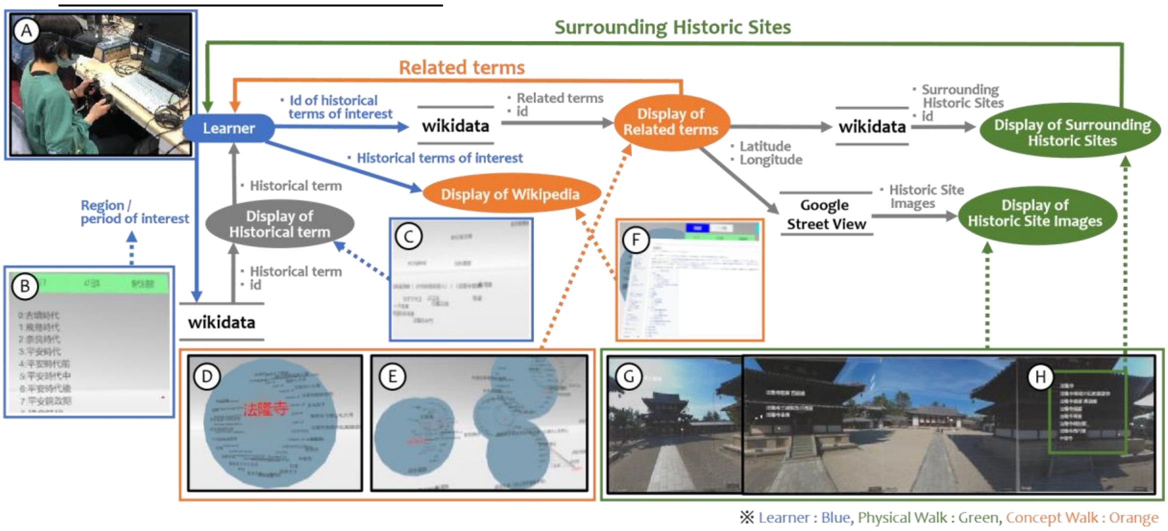

Figure 2. Realizing Physical Walk and Concept Walk.

he or she can explore and learn in Concept Walk mode. Learners can switch between the Physical Walk and Concept Walk on the UI.

★ Learning by Physical Walk

The scale and atmosphere of the historic site (e.g., Hōryū-ji Temple) (Fig. 2(G)) and its location in relation to surrounding historic sites (e.g., Chūgū-ji Temple) (Fig. 2(H)) can be observed. At this time, the system will obtain the latitude and longitude information of the site selected by the learner from WDQS, and place images of historical sites obtained from Google Street View Static API in the VR space to dynamically construct a pseudo-space around the historical sites.

Through Physical Walk exploration, the learner can expand their interest in history by observing the scale and atmosphere of the historical site, its location in relation to surrounding historical sites, and geographical information about the surrounding area.

★ Learning by Concept Walk

The term selected by the learner from among the historical terms and its related terms are visualized (Fig. 2(D)). The learner can follow the related terms with the controller, and the path can be confirmed by the change in the color of the letters of the terms that the learner has followed (Fig. 2(E)). If the learner selects a term, they can check the Wikipedia page (Fig. 2(F)). This exploration activity is intended to promote understanding of interested terms through understanding. At this time, the system obtains all the properties and values of the terms selected by the learner using WDQS, and visualizes the related words and phrases based on them.

★ Learning by going back and forth between Concept Walk and Physical Walk

Learners can conduct exploratory activities combining both Concept Walk and Physical Walk. When exploring Hōryū-ji Temple (Physical Walk), for instance, to understand that the temple was built by Prince Shotoku and that Chūgū-ji Temple is a nun temple that he built for his mother (Concept Walk), and then move on to the temple (Physical Walk) because it is near Hōryū-ji Temple where he is now. At this time, to integrate historical site image data, which does not retain semantic information, and historical terminology (and its semantic relationships), which does not retain spatial information, the system identifies the proper combination using a large-scale knowledge database (Wikidata) as a pivot to integrate Physical Walk and Concept Walk.

4. Pilot Evaluation Study

An evaluation experiment was conducted to confirm the potential of the proposed system in learning to explore historical sites. Five undergraduate and two graduate students who were using the Oculus rift for the first time were asked to use the system we developed. The students watched a demonstration video explaining how to use the system for about 3 minutes, and then studied for about 10 minutes using the system. After the study, the students were asked to respond to a five-point questionnaire.

Table 1. *Questionnaire Results*

Questionnaire Items	Average
(i) Did you have a better spatial understanding of the historic sites?	4.1
(ii) Did you understand the relationship between terms while learning?	4.0
(iii) Were you able to proceed with the learning according to your interest?	4.5
(iv) Did you have a greater interest in history?	4.2
(v) Did you connect to deeper learning by exploring historic sites and related terms?	3.8
(vi) Was the system easy to use?	2.5

Figure 3. Adaptive Learning Environment in an Open-ended Space.

The six questionnaire items were "(i) Did you have a better spatial understanding of the historic sites" from the viewpoint of the learning effect by Physical Walk, "(ii) Did you understand the relationship between terms while learning" from the viewpoint of the learning effect by Concept Walk, "(iii) Were you able to proceed with the learning according to your interest" and "(iv) Did you have a greater interest in history" from the viewpoint of supporting independent learning, and "(v) Did you connect to deeper learning by exploring historic sites and related terms" from the viewpoint of supporting in-depth learning. From the viewpoint of supporting independent learning, "(vi) Did you proceed with your learning in accordance with your interests?"

Table 1 shows the average scores of the questionnaire results. The average scores for (i) and (ii) were 4.1 and 4.0, respectively. This suggests that the Physical Walk can promote spatial understanding and the Concept Walk can promote understanding of related terms. It is expected to eliminate the difficulty of learning that it is not easy to support learning with a sense of space and learning with many terms structurally related to each other when learning with textbooks. The average scores for (iii) and (iv) were 4.5 and 4.2, respectively, suggesting that the system provided learning opportunities that followed the learners' interests and that the presentation of detailed and relevant information through the exploration of historical sites and related terms motivated the learners to learn history. In fact, positive comments such as "I enjoyed learning as if it were a social studies field trip," and "I felt my knowledge expanding through the expression of the expanding network when I selected a term, and I wanted to expand it further. On the other hand, the average score for (vi) was 2.5. Usability needs to be further improved. The score of 3.8 for item (v) suggests that the user is required to become accustomed to the operation while wearing the Oculus rift.

5. Towards Question Generation Based Support in VR-Based Open Learning Space

One of the main characteristics of the system developed in this research is its generality. The method of implementation presented in this paper allows one to provide learners with an open-ended learning space that is adaptive to their interests without rewriting the program, no matter what the age of the learners in any region.

Figure 3 shows the learning environments provided at Machu Picchu, Peru in the 14th century; Piazza Iran, Iran in the 15th century; Colosseum, Italy in the 1st century; and Angkor Wat, Cambodia in the 12th century.

On the other hand, the information in Concept Walk mode is currently presented as it is in Wikidata. Although the information is stimulating to expand learners' interests and concerns, more active support is desired as a stimulus to induce meaningful learning. In our previous studies, we have developed a mechanism to dynamically generate meaningful questions based on Linked Open Data, Question Generation Ontology and History Domain Ontology for learners learning history in an openended learning space, and have confirmed the quality of these questions and their learning effects (Corentin, Seta & Hayashi, 2016; Corentin, Seta & Hayashi, 2017).

In the learning environment realized in this paper, we would like to realize more active support to deepen learners' learning by making it possible to generate questions that follow learners' learning.

6. Concluding Remarks

We have realized an open learning space combining spatial and semantic information that follows learners' interests via Wikidata and Google Street View, and confirmed its potential to promote independent and deep learning. The Asuka period is taken as an example in this paper, but the proposed system is characterized by its generality and scalability to work in different periods and locations.

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Training System for Learning Tactics from E-sports Playing Video Based on Explanations

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Abstract: In e-sports, the play videos of skilled players are good learning materials for beginners who want to acquire and learn tactics. Tactics are a series of actions that are taken to accomplish various objectives in response to a situation. When learning tactics from videos, players need to select meaningful actions. However, discriminating whether actions are meaningful for forming tactics is difficult. Our research supports players who want to acquire the skills of identifying meaningful actions from playing videos because such actions have causal relations with each other. If players can explain the causal relations of the extracted actions, this ability suggests that they have indeed extracted appropriate actions. This paper constructs a system that gives a playing video that contains a scene with important tactics and provides an environment in which players can explain them in the video. It also gives feedback about the appropriateness of the extracted actions.

Keywords: tactics acquisition, play videos, e-sports, scene explanations, causal relations

1. Introduction

E-sports is an abbreviation for "electronic sports," a name that refers to computer games as athletic competitions. E-sports is attracting more and more attention each year, over 70 million people watch E-sports over the Internet or on television globally, and the number of people who annually compete in such activities is also growing (Jenny et al., 2017). In e-sports, players engage in competitions by repeatedly making decisions on actions based on the current situation. Appropriate actions are based on tactics that consist of objectives for the game situation and a series of actions based on the objectives. If players just know a few actions, they will struggle to choose actions that increase their chances of winning. To succeed, players must know many tactics beforehand.

Learning from skilled players is one method for acquiring tactics, although such opportunities are generally scarce for novice players. To solve the lack of teachers, several learning support systems provide the role of a teacher and impart knowledge instead of a human teacher (Melis, et al. 2004, Carbonell, 1984). These systems need to have the knowledge they teach as teaching materials. However, in the field of e-sports, the tactics taught are often implicit; general teaching materials do not exist.

As a preliminary step to teaching tactics, Yang et al. extracted tactics for a battle game. They modeled combat as a graph structure showing the interactions of characters in a game genre called Multiplayer Online Battle Arena (MOBA) and extracted winning patterns from the changes in graph features (Yang et al., 2014). In their graph structure, since links only represent defeats or attacks, the extracted winning patterns just denote a series of defeating or attacking actions. Their approach cannot be considered tactics because it fails to clarify what actions should be taken in response to situations.

Researches have addressed support for tactical acquisition in more conventional sports. For example, Nishida et al. developed a system that targeted tennis tactics that analyzes the position of the ball and each player from video and presents the next action as a tactic based on the analysis results and the tactical knowledge held by the system (Nishida et al., 2011). By looking at the information presented by this system, the next action in response to a situation can be acquired as a tactical move. However, even though some tactics consist of more than one action, this system only focuses on tactics comprised of just one action.

Since the sequences of human actions are an embodiment of tactics (Shikata et al., 2020), observing effective scenes of the videos of skilled players and extracting the action sequences contained in them might be a good method for acquiring tactics with several actions. Good, effective scenes consist of a series of actions, although not all actions necessarily constitute a tactic. Therefore, we must identify only the critical action sequences that form tactics. Extracting the action sequence and causal relationships between actions from playing videos is the same as explaining the good points of plays in the videos. Learning by explanation is regarded as one of the effective learning methods for organizing the acquired knowledge by (Aleven et al, 2002), so our research introduces the explanation for selecting the important actions to support players who want to acquire the skill of finding meaningful actions from playing videos.

Since critical actions lead to the achievement of objectives, a causal relationship exists between the selected actions and objectives. For example, when allies and enemies are rather far apart, the following action sequence, "*move closer to the enemy* and *attack at short range*," is an appropriate tactic because the latter action can be taken only in a situation that includes both allies and enemies, as derived by the former action. If the players can extract such action sequences, they will successfully acquire tactics. Our research constructs a system that provides playing videos that contain a scene with important tactics and an environment in which players can explain the tactics dramatized in the videos. In actions with causal relations, situations derived by the former action lead to the latter action. Therefore, the system gives feedback by judging whether the extracted action sequences have appropriate causal relationships.

2. Overall Framework of a Training System of Learning Tactics from Playing Videos

The aim of this research is to help players acquire skills for learning tactics from play videos. Our system gives a video that functions as a question and lets a player explain her tactics as an answer. It gives feedback if her answer's explanation does not satisfy the constraint of the actions with causal relations. Fig. 1 shows the system configuration. The system consists of an interface that allows players to input explanations, a video database that stores the play videos of good scenes and their start and end situations, and an explanation-evaluation function. The interface gives players video of a play in which a certain objective was achieved and a description of its start and end situations. After receiving the player's explanation of the video, the explanation-evaluation function determines whether the actions of the input explanation have a cause-and-effect relation and gives feedback if there are actions without causal relationships. If the players selected action sequences that do have cause-and-effect relations, they successfully acquired a skill for learning tactics from a playing video.

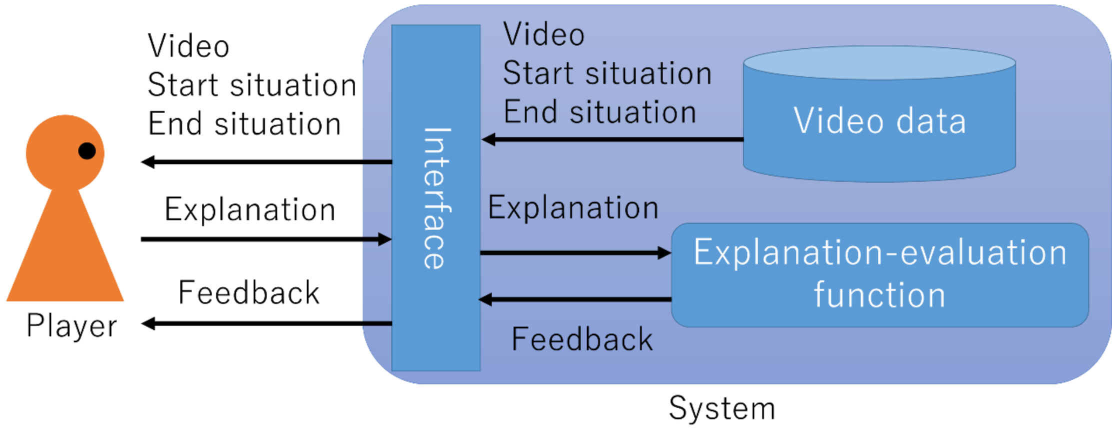


Fig. 1 System configuration

3. Format of Explanation

In e-sports, since the competition's situation is changed by player actions, a game is defined by sequences of situational elements and actions (Fig. 2). An explanation is a subset of the situational elements and actions that have cause-and-effect relations.

In the explanations, the reasons for selecting the actions must be described. As mentioned in Section 1, in actions with causal relations, situations derived by the former action lead to a latter action. Therefore, situational elements that are derived by the former actions and those that trigger the latter actions become the reasons for selecting them.

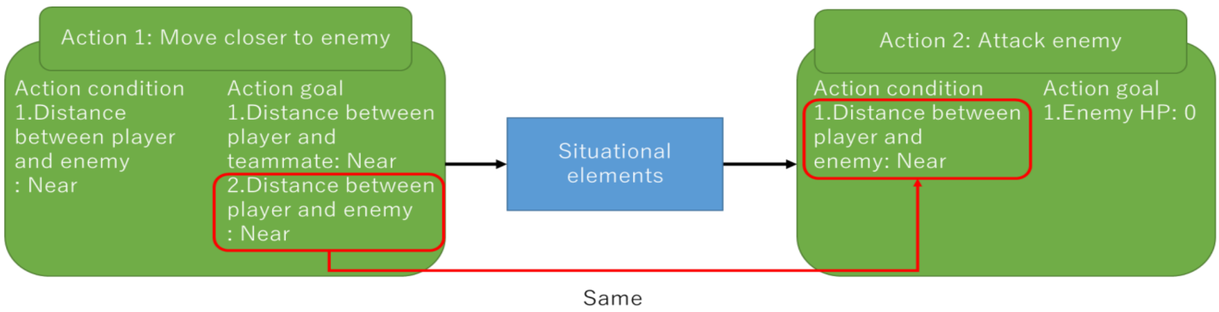
Our system lets players explain the given scenes by indicating actions that seem important, the situational elements that serve as the condition for taking an action (*action condition*), and the situational elements that are changed by the action (*action goal)*. For example, if "*move closer to the enemy*" action seems important in the video, "*the distance from the enemy is long*" action condition and "*the distance from the enemy is short*" action goal must also be input.

Fig. 2 Explanation format

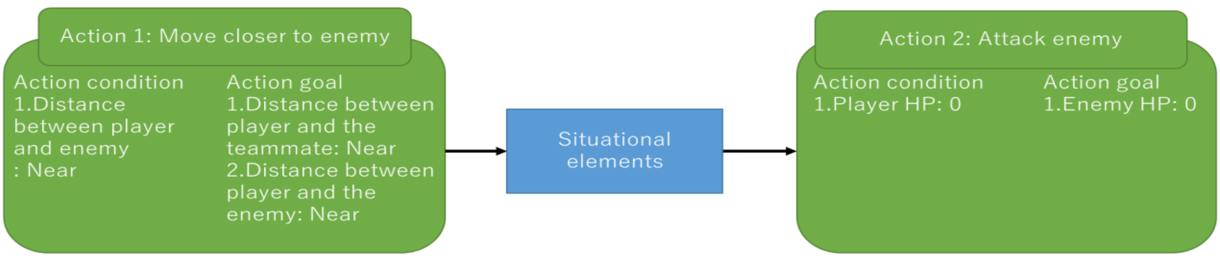
4. Explanation-Evaluation Function

The explanation-evaluation function determines whether the descriptions of the actions input by players have cause-and-effect relations. The action condition of the latter action and the action goal of the former action are used to evaluate whether a cause-and-effect relation exists between two actions. If the action condition of the latter action is included in the action goal of the former action, the two actions are defined as having a cause-and-effect relation.

Figure 3 shows examples of two actions. In Fig. 3a, since both the action goal of Action 1 and the action condition of Action 2 show "Distance between you and enemy: near," Action 2 is defined as the effect of Action 1. In Fig. 3b, since the action goal of Action 1 and the action condition of Action 2 do not have the same situational element, they have no cause-and-effect relation.



a) Actions with cause-and-effect relation



b) Actions with no cause-and-effect relation Fig. 3 Example of selected actions

The explanation-evaluation function checks the action goal of the former action and the action condition of the latter action for every pair of continuous actions and, if the situational elements are not identical, the player is led to find different actions that have cause-and-effect relations.

5. Prototype System

We implemented our proposed system in C#. Its main screen is shown in Fig. 4. The play video that the player must watch and explain is shown in the video area. The created explanation is shown in the explanation-display area. The videos were played on a Windows Media Player.

When the system begins, only the start and end situations of the play in the video are given in the explanation-display area. Therefore, the player needs to select actions that connect these given situations and input them into the system. This system provides two methods for creating explanations: adding a next action and its action goal for the given situation (*forward explanation*), and adding a former action and its action conditions for the given situation (*backward explanation*). When adding actions, the player needs to select a method from the explanation–method-selection area. After selecting it, the explanation-input screen emerges (Fig. 5). The player edits or deletes the created explanation by pushing the explanation-edit button to move to the edit-explanation screen whose contents are identical as the explanation-input screen. When the player finishes inputting her explanation and pushes the explanation-complete button, the system determines whether the actions in the created explanation are appropriate; if they are not, it gives feedback: e. g. “There is no cause-and-effect relation between Actions 1 and 2.”

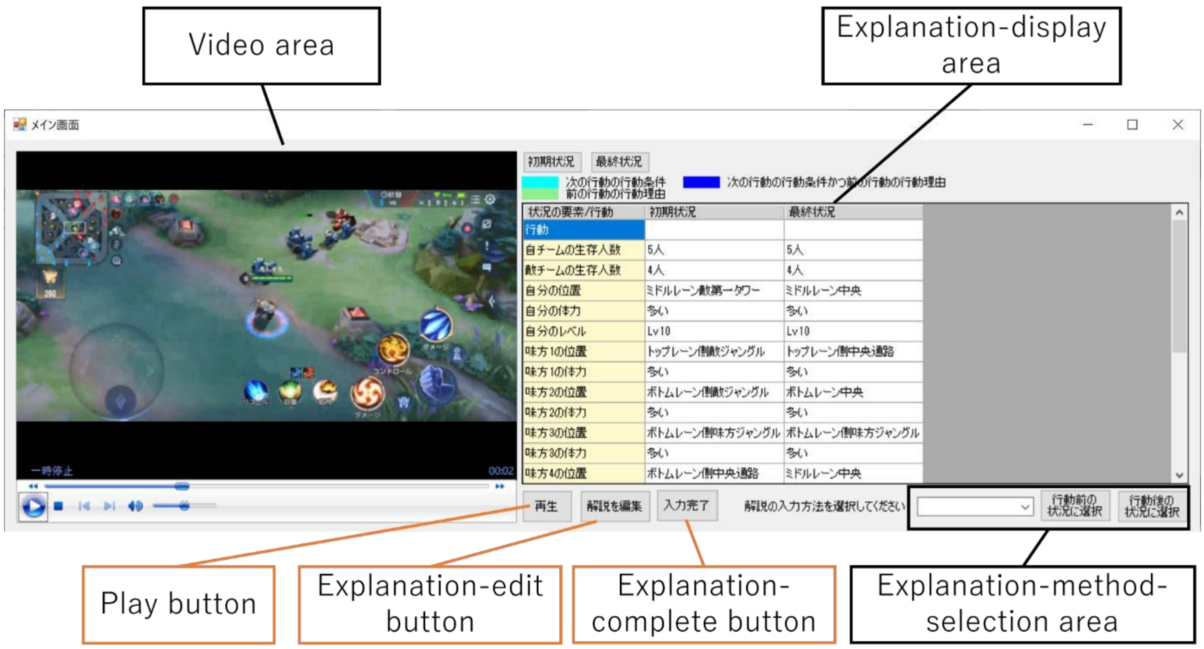


Fig. 4 Main screen

Figure 5 shows the explanation-input screen. Other than the explanation-input area, its layout is identical as the main screen. In the explanation-input area, the action, the action condition, the action goal, and the post-action situation can be input. To simplify the players’ ability to grasp the situation, the system provides the elements of the situation and their values as candidates and lets one to be selected. The current system focuses on the MOBA game genre and provides the elements of the situation and their values (Table 1). In MOBA, multiple players are divided into two teams, and each player controls a character and cooperates with teammates to destroy the enemy towers. By inputting to the explanation-input area and pushing the add button, the input action and its next/former situations appear in the situation-display area.

Table 1 Elements and values of situations

Elements	Values
Character location	Enemy team's tower, player team’s tower, jungle, etc.
Character HP	Big, half, small, zero
Character level	1 to 15
Number of towers	0 to 9
Tower HP	Big, half, small, zero
Field monster HP	Big, half, small, zero
Distance between characters	Long, short

Fig. 5 Explanation-input screen

6. Evaluation Experiments

6.1 Experimental settings

We experimentally evaluated the effectiveness of our system. As the first step for acquiring skill, the system only supports players to create explanations that satisfy the cause-and-effect relations. Therefore, the experiment evaluated how effectively the system support players to generate causally connected explanations, how well it support players to acquire tactics, and the interface’s operability.

As playing video data, we prepared two videos of a MOBA game called “Arena of valor.” The first 7-second video includes a “*move closer to an enemy to attack*” tactic, and the second is a 25-second video that includes the following complicated tactic: a “*defeat the field monster, move near the enemy, attack it, move near the field monster, and attack it.*” Unfortunately, our experiment only had five university students who had not played MOBA games and one university student who had played them several times as participants due to COVID-19 effects. They belonged to the computer science department and were recruited for this experiment.

First, our participants watched the videos and described the tactics used in them (Step 1). Next, they used the system to explain the scenes of the same videos (Step 2). Then, they described the tactics again (Step 3). Finally, they filled out a questionnaire (Step 4).

The questionnaire used in this experiment is shown in Table 2. Question 1 investigated whether using the system simplified the creation of the explanations, and participants answered on a 4-point scale: yes, somewhat yes, somewhat no, and no. If they answered somewhat no or no, they chose a reason from the following options: "interface is difficult to use," "important situations/actions are difficult to find," and "other." Question 2 asked about the operability of the interface, and participants answered on a 4-point scale: yes, somewhat yes, somewhat no, and no. If they answered somewhat no or no, they described the reason. Question 3 asked about the feedback's effectiveness, and those who received feedback from the system answered by selecting from "yes" or "no." If they answered "yes," they chose the reason from the following options: "I didn't understand the feedback," "I didn't know where to correct," or "other."

Table 2 Questionnaire items

Q1	Was it easy to create explanations using the system?
Q2	Was it easy to use the interface?
Q3	Was it difficult to modify the explanations based on the feedback?

6.2 Results

We evaluated the system's effectiveness for acquiring tactics by comparing the action sequences of the tactics described in Steps 1 and 3 with those of the expected tactics. Table 3 shows the results. Participant *F* of Video 1 and participants *A* and *B* of Video 2 were unable to extract the appropriate action sequences in Step 1, although they did extract the appropriate one in Step 3. Participant *F* extracted the "gain experience" action in Step 1 in Video 1. By using the system in Step 2, he realized that the action was irrelevant to the tactic and removed it, suggesting that the system contributed to the acquisition of tactics. On the other hand, participants *D* and *E* of Video 2, who could not extract the assumed action sequence in either Steps 1 or 3, also failed to extract the "move toward the field monster" action. In Step 2, they input the "move toward the field monster" action to the system as an explanation, although they did not appropriately describe the situational elements for finding the cause-and-effect relations. Had they appropriately observed the situational change, they probably would have extracted an appropriate action sequence as a tactic.

We evaluated how effectively the system support participants to generate causally-connected explanations based on whether they were generated in Step 2 and in the Q1 and Q3 results. Table 4 shows the results about whether the explanations with causal relationships were made in Step 2, and Table 5 shows the questionnaire results. From Table 4, no one created an explanation with cause-and effect action sequences in Video 2, although participants *C* and *E* created explanations with cause-and effect action sequences in Video 1. Participant *E* initially failed to create an appropriate explanation. Based on the system's feedback, he modified his explanation and successfully created an appropriate one. Unfortunately, for the other cases, the system's feedback did not improve the explanations. From the Q1 result in Table 5, participants *A*, *B*, and *E* answered "somewhat no" to the ease of creating explanations. In addition, the Q3 result shows that five out of six participants answered "yes" to the difficulty of revising the explanation through the system's feedback. The difficulty reflected that the system only indicates two actions that do not have a cause-and-effect relation, and so participants did not understand why the indicated actions were inappropriate. These results show that the system's feedback was insufficient to help participants create appropriate explanations.

We evaluated the interface's operability by the Q2 result, which shows that half of the participants answered "somewhat yes," and the other half answered "somewhat no" about the ease of using the interface. In addition, many participants answered that inputting the situations and actions into the system was difficult. This result shows that our system's interface is not very user friendly and it must be improved for entering situations and actions.

Table 3 Are extracted action sequences identical as expected action sequences?

Participants	Video 1		Video 2	
	Step 1	Step 3	Step 1	Step 3
A	Y	Y	N	Y
B	Y	Y	N	Y
C	Y	Y	Y	Y

D	Y	Y	N	N
E	Y	Y	N	N
F	N	Y	Y	Y

Table 4 Were appropriate explanations made with system? (in Step 2)

Participants	Video 1	Video2
A	N	N
B	N	N
C	Y	N
D	N	N
E	Y	N
F	N	N

Table 5 Questionnaire results

Cooperators	Q1	Q2	Q3
A	Somewhat no	Somewhat no	Yes
B	Somewhat no	Somewhat yes	Yes
C	Somewhat yes	Somewhat no	No
D	Yes	Somewhat yes	Yes
E	Somewhat no	Somewhat yes	Yes
F	Somewhat yes	Somewhat no	Yes

7. Conclusion

We proposed a method that acquired tactics from the play videos of skilled players by choosing action sequences that have cause-and-effect relations as explanations. We also developed a system that supports players who create explanations for the given videos as the first step for developing skills for finding actions that form tactics. The system gives feedback when the selected action sequences lack cause-and-effect relations. Our evaluation experiment suggests that players derived tactics after using the system, although its feedback did not help them create explanations with the actions of cause-and effect relations. Unfortunately, we haven't yet evaluated our system in the context of acquiring skills for finding effective actions. We need further experiments to evaluate how the system contributes to support acquiring skill.

Our method for supporting players to identify and acquire tactics from the playing videos of skilled players is appropriate for tactics that have only one cause-and-effect relation path. However, there are usually tactics whose actions have several causes and who affect to several actions. We need to improve our system to cope with such tactics.

In addition, our method can apply to tactics that can improve situations, since it is easier to choose good actions. However, other tactics can be used to avoid worsening game situations and maintain the current situation. Such tactics are difficult to acquire by observing play videos. To grasp them, players need to anticipate the future situation based on the current situation. If the anticipated situation is worse but the play video does not get to that worse situation, players will notice the tactics for maintaining the current situation. So we should introduce to our method the phases that anticipate future situations and compare anticipated situations and those in the video.

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The Effect of Contextual Student-Generated Questions on EFL Learners' English Learning Performance, Language Learning Strategy Use, and Perceived Cognitive Load

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Abstract: The importance of learning English has been widely recognized in the English as a Second or Foreign Language (ESL/EFL) context and effective teaching and learning approaches to enhancing English learners' linguistic and pragmatic knowledge have been called for. The purpose of the study aimed at comparing the effect of a contextual student-generated question (cSGQ) strategy on English learning performance, learning strategy use, and perceived cognitive load. A quasi-experiment with pre-and post-test was employed and the results based on the analysis of covariance technique showed that students in the cSGQ group outperformed those in the SGQ group in terms of English learning performance. However, no significant differences in learning strategy use and cognitive load were found between the two groups.

Keywords: Contextual learning, English learning, innovative teaching and learning approaches, online learning activities, student-generated questions

1. Introduction

1.1 The Present Situation and Obstacle of English Teaching and Learning for University Students in Taiwan

English curricula have been incorporated into programs for students of all majors in Taiwan, and most universities in Taiwan have set different levels of English proficiency as one of the graduation criteria (Wu & Wu, 2010). In other words, regardless of majors, most university students in Taiwan should achieve a certain level of English proficiency to get a university diploma.

As one of the required courses for Taiwanese university students, the issue of how to facilitate students in the English as a Foreign Language (EFL) context to improve their English proficiency has caught much attention. Although the curricula for English teaching and learning in Taiwan have undergone great changes in the past few decades, the widely used technique is still the traditional teaching method (Chang, 2011) with a lot of translation and rotation such as the Grammar Translation Method (GTM) (Prator & Celce-Murcia, 1979) with its focus on the accuracy of direct translation and Audio-lingual Method (ALM) with its focus on the repeated linguistic structures for English learners (Fries, 1945).

However, such practice was found to hinder Taiwanese learners from developing pragmatic functions of the language (Lan, 2015). That is, students taught with traditional methods such as GTM would heavily rely on teachers' instruction and explanations (Chang, 2011) on the grammatical translation rules and rotated memorization of sentence structures, where students develop their target language proficiency in a de-contextualized learning environment. Also, repeated memorization and rote learning of sentence structures, as stressed by ALM, provide students with limited chances to actually use the language (Chang, 2011), which prevents learners from developing communicative competence in English.

1.2 Student-generated Questions and Contextual Student-generated Questions Tasks and the Benefits for Learning

Student-generated Questions (SGQ) refers to the teaching and learning strategy where students generate questions and corresponding answers to demonstrate their level of knowledge and understanding of the targeted learning materials (Yu & Wu, 2020). Several advantages associated with SGQ have been found for learners, such as confirming one's own understanding of the learning contents, resolving misconceptions, and fulfilling knowledge gaps (Chin, 2002; Juan, 2021; Offerdahl & Montplaisir, 2014).

The effectiveness of SGQ on learning has been widely recognized in the past few decades (Foster, 2011; Juan, 2021; Khaki, 2014; Mays, Yeh & Chen, 2020; Offerdahl & Montplaisir, 2014). For example, the use of SGQ in math class was found to be effective in enhancing learners' affective perceptions on account of the autonomous nature of SGQ tasks (Foster, 2011). Moreover, elementary school students' English reading ability was proved to be significantly enhanced after the SGQ tasks, and improved engagement and interest in learning English were reported (Mays, Yeh & Chen, 2020). SGQ was also used as a reading strategy for students to further enhance English reading comprehension (Khaki, 2014). When completing the SGQ learning tasks, learners are provided with the opportunity to actually use English (Mays, Yeh, & Chen, 2020).

Different from SGQ, contextual student-generated Questions (cSGQ), an elaborated approach to SQG proposed by Yu (2021), stresses the provision of a context for students to generate questions. That is, under the cSGQ arrangement, students are given a specific scenario around which to generate questions. As the generated questions are expected to correspond to the given scenario, reflecting the situational clues and details of the given context (such as the characters in the story and the timeline of the events), students should not only attend to the targeted English but also detect and analyze important information within the given context for successfully completing the cSGQ learning tasks. Despite its potential, research on cSGQ's effectiveness is very limited. Up till now, only few studies focusing on exploring the effect of cSGQ on English learners and for those that did (e.g., Cheng & Yu, 2021; Lin & Yu, 2021), they only examined the effectiveness of cSGQ on English grammar learning and SGQ task completion and task performance. As such, the potential of cSGQ should be further investigated, specifically, the effect of cSGQ on learning strategy use and perceived cognitive load is focused in this study to provide better insights into the application of cSGQ into English curriculums.

1.3 Language Learning Strategy Use

Apart from the interest in effective English teaching pedagogy, other factors influencing the success of developing target language proficiency have also caught the attention of both the teaching practitioners and researchers in this field, such as the use of learning strategies. Learning strategies refer to the conscious mental activities and behaviors learners employ and activate for the attainment of learning goals (O'Malley, Chamot, Stewner-Manzanares, Russo, & Kupper, 1985). According to Oxford (1990), direct strategies, including cognitive strategies, memory strategies, and compensation strategies have been widely applied and researched. Cognitive strategies have been not only associated with higher levels of cognitive process, but also linked with methods employed by the learners to enhance their learning performance such as memorizing, repeating, and relating (Costley, 2020). Memory strategies suggest the effective measures students use to get familiar with the learning materials, such as rote learning (Zhou, 2018). Compensation strategies are the needed measures used by the learners when they are faced with challenging situations such as asking for help and searching for information on the Internet (Syafryadin, Martina & Salniwati, 2020).

The use of learning strategies has been found to be associated with better learning performance. For example, a significant relationship between the use of learning strategy and their learning performance in English was found in the study conducted by Azizmohammadi and Barjesteh (2020). Also, the use of learning strategies was found statistically significant related to English listening performance (Irgin & Erten, 2020).

1.4 Cognitive Load

Cognitive load refers to learners' perception toward the assigned tasks and concerns limited facilities of working memory (Costley, 2020; Paas, Renkl, & Sweller, 2004). That is, when engaged in the learning tasks, learners would self-perceive the amount of information and mental effort required in the process of completing the learning tasks. The proponents of cognitive load theory suggest that the design and presentation of instruction and learning materials should correspond to the "significant limitations" of the human capability of processing the presented information (Pass, van Gog, & Sweller, 2010; Sepp, Howard, Tindall-Ford, Agostinho, & Pass, 2019). The instructional design and provided materials should be appropriate for learners' cognitive capacity to process and should avoid overloading the cognitive demand during the process of learning (Mutlu-Bayraktar, Cosgun, & Altan, 2019). Thus, it is crucial to understand students' perceived cognitive load when innovative designs for instruction are used such as cSGQ learning tasks in this study.

1.5 The Purpose and Research Questions of the Study

During the process of cSGQ for English learning, it is anticipated that students not only use targeted English as the focus for the formation of their questions but also would detect and analyze important clues and pragmatic functions of using the language embedded within the given context. That is, when completing cSGQ learning tasks, students should not only fulfill the requirements of the SGQ task but should also use the information from the given context for question generation, which reflect the information from the given scenario with the hope to develop communicative purpose and pragmatic functions of using English. Additionally, when applying such innovative pedagogical design such as cSGQ into English curriculums, many factors influencing the success of developing target language proficiency should also be considered, such as the use of learning strategies involved in the process of completing the cSGQ learning tasks and perceived cognitive load regarding the instructional design of the cSGQ learning activity.

With the focus on exploring the learning effect of cSGQ and resolving possible issues mentioned above as faced by English learners, the present study is designed to investigate the potential effect of cSGQ and SGQ learning activities on English learners in terms of English learning performance, the use of learning strategies and perceived cognitive load. Specifically, three research questions are examined in the study:

RQ#1 Do students in the cSGQ group have better English learning performance than those in the SGQ group?

RQ#2 Do students in the cSGQ group employ more learning strategies than those in the SGQ group?

RQ#3 Do students in the cSGQ group perceive more cognitive load than those in the SGQ group?

2. Method

2.1 The Participants and Study Context

In the present study, three classes with 79 university students in southern Taiwan were recruited and randomly assigned to two treatment groups: the cSGQ with 42 students and SGQ group with 37 students. The course was a required general course called 'Freshman English for all Non-English Major Freshmen.' The pre-test results indicated that the English proficiency between the two groups was similar ($F = 0.856$, $p = .358$). All of the participating students didn't have prior experience in SGQ before the experiment and their English proficiency level was B1 based on the Common European Framework of Reference for Languages: Learning, Teaching, Assessment (CEFR).

2.2 The Learning Materials

The course is a general education course for university freshmen and the textbook used in the study was selected by the language center of the participating university. The selected topics for the English learning activity were tenses and subjunctive moods, which were incorporated into two separated lessons in the textbook. After the instruction on the two selected topics, the students were asked to generate questions as online learning activities.

2.3 Instruments

The pre- and post-test test consisted of 50 questions with 25 for tenses and 25 for subjunctive moods, respectively, to assess student English learning performance. If the student gets one of them correct, he/she will get 2 marks. The test questions were constructed by the first author and further examined by two professors with more than ten years of teaching English for ESL and EFL learners in Taiwan. Also, it should be noted that 18 questions were specifically for the knowledge of grammatical structures and seven questions for evaluating learners' understanding of using the knowledge within the context. For the subjunctive moods, again 18 questions were for the grammatical knowledge and 7 questions for assessing contextual understanding on the usage of within the given context. As an example of the latter, A: Do you want to go to the movie with me tonight? B: I did with May. Clearly, the utterance from B contained the usage of past tense and involved the contextual meaning. As can be understood, students not only need to identify the correct tense of the sentence but also apply the linguistic knowledge into the context to successfully decode the contextual meaning of the sentence.

A questionnaire on learning strategy use with 40 questions and cognitive load with 10 questions was employed before and after the experiment to explore students' learning strategy use and cognitive load while exposed to the two teaching and learning approaches. The questionnaire on the use of English learning strategies was based on the English learning strategy scale (SILL, Strategy Inventory for Language Learning), which was compiled by Oxford's (1990) Language Learning Strategies and includes memory, cognition, and compensation strategies. The Cronbach's alpha value was 0.866 for memory strategies, 0.819 for compensation strategies, and 0.92 for cognitive strategies. As evidenced by the data obtained from the participants of the study, it was excellent in terms of consistency and robustness (Bao, 2010).

The questionnaire used to examine students' perceived cognitive load was based on the study conducted by Kuan (2016), with ten questions on a seven-point Likert scale. The correlation of the two factors (i.e., mental effort and confidence and performance) conducted by Yu and Lin (2020) reached .60. The sum of the scores from all questions suggests students' perceived cognitive load toward the learning activity in the study.

2.4 The Online Learning Systems

Two learning systems with similar system structures were used for the two treatment groups — Testlet (Yu, 2021) for the cSGQ group and QuARKS (Yu, 2009) for the SGQ group. The interface of QuARKS is shown in Figure 1, with the major fields and functions provided for students to generate questions while the interface of the Testlet is shown in Figure 2. As can be seen in Figures 1 and 2, both systems have similar functions, support the generation of questions, and allow students access to a set of built-in online procedural prompts with context-appropriate examples as scaffold of question-generation. In essence, the main difference between the two systems lies in Testlet having an additional field reserved for the given context (see the top portion of Figure 2) for students in the cSGQ group to base their generated questions on.

Figure 1. The Screenshot of the Areas and Procedural Prompts for Students in SGQ group on QuARKS.

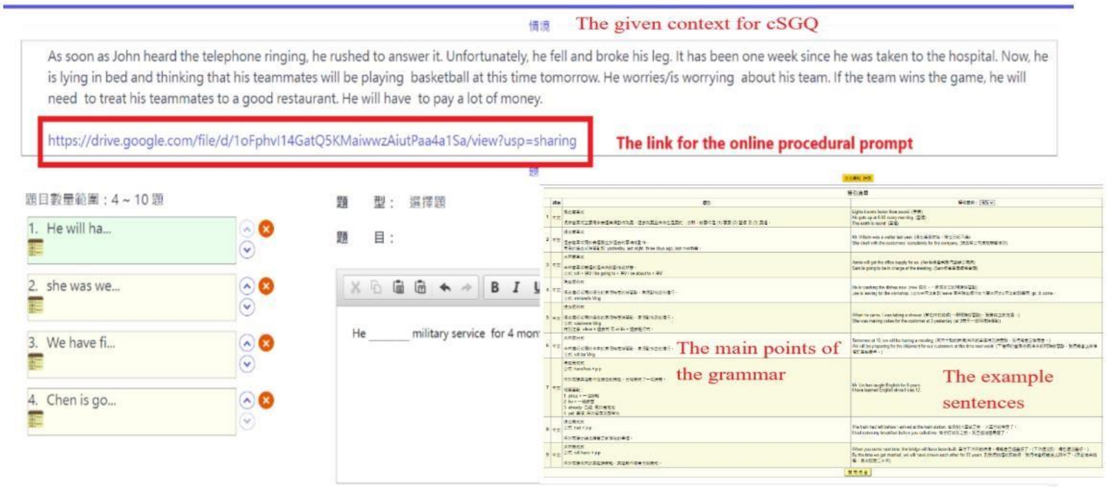

Figure 2. The Screenshot of the Areas (with a reserved column for the given context on the top) and Procedural Prompts for Students in cSGQ group on Testlet.

2.5 Research and Study Design

A quasi-experimental research with the pre- and post-test design was employed. The independent variables are the two online SGQ learning tasks: cSGQ and SGQ learning activity, and the dependent variables include the participants' learning performance on the two targeted English, the use of learning strategies and perceived cognitive load toward the two designs of learning activities in the present study.

The research procedure was depicted in Figure 3. Before the experiment, all of the students in the two groups were asked to take the pre-test on the English learning and the pre-questionnaire on learning strategy use. After the learning activity on week five, all the students were asked to fill the pretest perceived cognitive load toward the SGQ learning activity questionnaire.

The post-test on the first targeted English grammars, tenses, was conducted on week nine. After finishing the fourth online learning activity, all the students were asked to complete the same perceived cognitive load questionnaire again. On week 17, the students finished the use of learning strategies questionnaire and on week 18, a post-test on subjunctive moods was conducted to assess their learning.

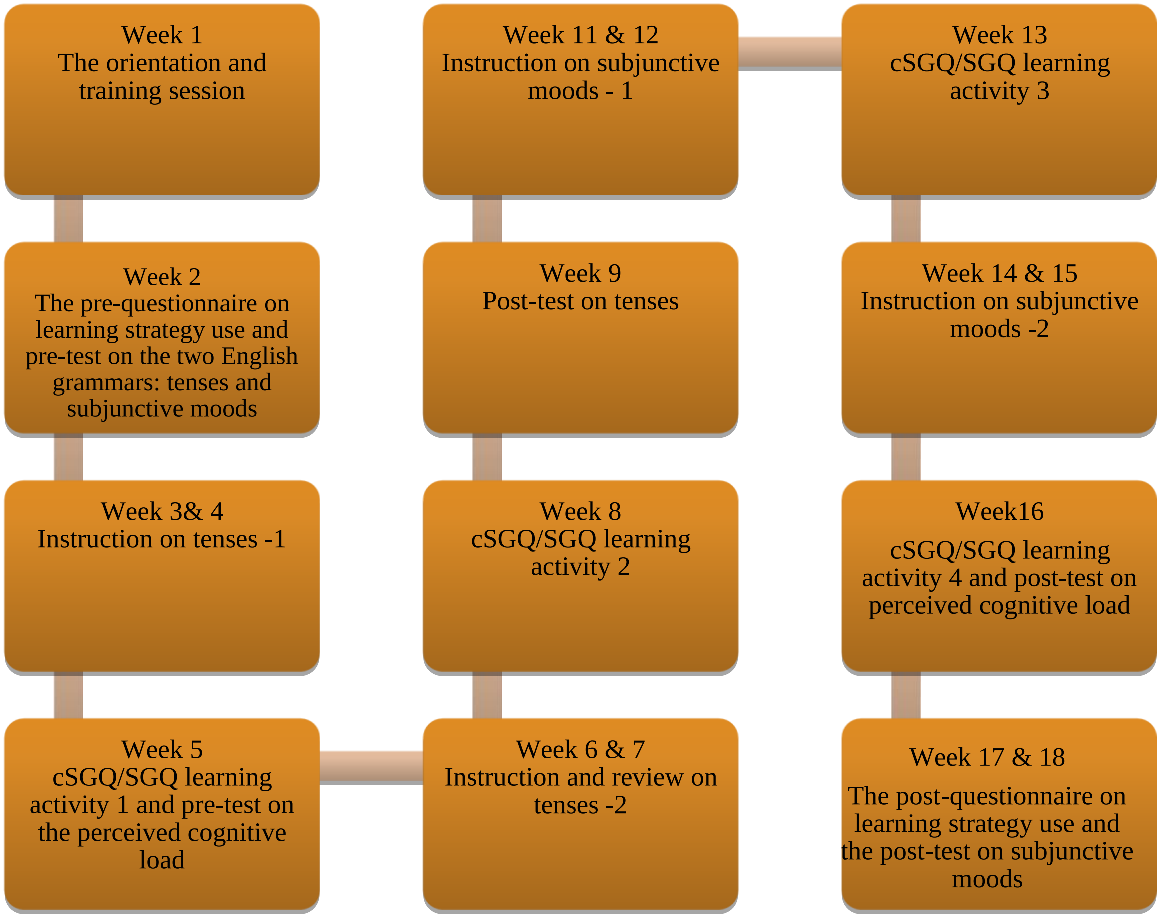

Figure 3. Experimental Procedure of the Study.

2.6 Data Analysis

To examine the effectiveness of cSGQ learning activity on EFL learners, the one-way analysis of covariance (ANCOVA) was performed on SPSS (version 23), using the scores of the pre-test as covariates. After ensuring the homogeneity, one-way ANCOVA was performed to compare the difference between the cSGQ and SGQ groups in terms of learning performance on the two targeted English, the use of learning strategies and perceived cognitive load.

3. Results and Discussion

3.1 English Learning Performance

The assumption that the regression coefficients between the two groups was homogeneous was satisfied, F = 0.856, p = .358. As shown in Table 1, the results of ANCOVA showed that the difference between the two groups reach the level of significance, F = 12.278, p = .001.

Table 1. *Descriptive Statistics and the ANCOVA Result of English Learning Performance*.

Groups		Mean (*s.d.*)[+]	Adjusted Mean	*F*	*p*
cSGQ group (*N*=42)	Pre-test	59.83 (9.88)	71.07	12.278	.001
	Post-test	69.66 (7.5)			
SGQ group (*N*=37)	Pre-test	52.04 (7.85)	64.72		
	Post-test	66.32 (8.66)			

[+] s.d.: standard deviation

As expected, students in the cSGQ group would have better English learning performance because in the process of completing cSGQ learning tasks, they would not only need to fulfill the requirements of SGQ learning task, but also pay further attention to the given contexts in order to generate questions congruent with the given scenario. Such process would trigger learners' awareness to the details within the given context, detecting essential clues and information regarding the usage of English, leading to better English learning performance. As illustrated by the example question generated by one participant of the cSGQ group (Figure 4), before embarking on question-generation, students in the cSGQ group would need to decode the given context so as to extract essential information (e.g., the time and sequence of the action). Then, they would employ both the linguistic knowledge (e.g., the usage of past tense, linguistic structures of forming questions) and situational information they detected from the context (e.g., the main character of the story, the sequence of action in the given context) for successfully completing the cSGQ learning tasks. The processes involved in applying the learned linguistic knowledge to the given context may raise learners' attention to both the linguistic clues and contextual awareness, leading to the development of pragmatic competency of using English (by combining the linguistic knowledge and situational information) and overall enhancement of language proficiency.

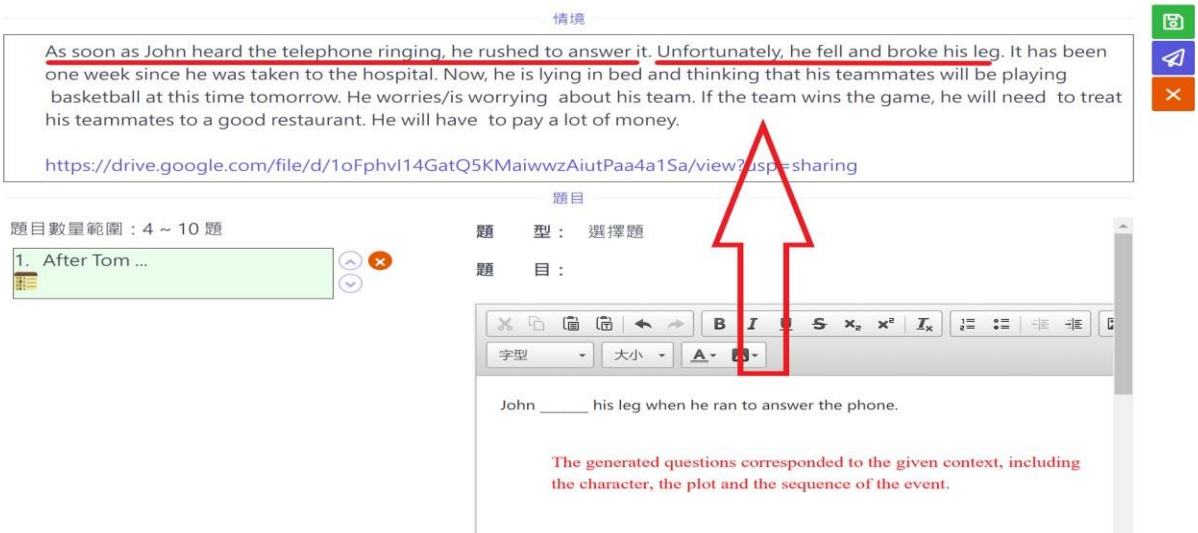

Figure 4. The Example Question Generated by One of the Participants in the cSGQ group.

3.2 The Use of Language Learning Strategies

The ANCOVA was performed to see whether the use of language learning strategies differ between the two groups after the treatment. Table 2 showed the results of language learning strategy use. No significant differences were found between two treatment groups in terms of memory strategy (F = .385, p = .656), compensation strategy (F = .103, p = .469) and cognitive strategy (F = .241, p = .475).

While no instruction on how to use learning strategies was provided for either group, with the additional scenario given for the cSGQ group, we expected that more use of strategies (such as analyzing the context, and applying the situational information) would be required of the cSGQ group. Nonetheless, our data did not confirm our hypothesis. One possible reason for there being no statistical significance may lie in the limited times of cSGQ learning tasks. In the present study, there were only three times for cSGQ learning tasks, which might prevent students in the present study from developing habits of using these language learning strategies.

Table 2. *Descriptive Statistics and the ANCOVA Result of the Use of Language Learning Strategy*

Memory strategy

Groups		Mean (s.d.)+	Adjusted Mean	F	p
cSGQ group (N=42)	Pre-test	41.29 (7.98)	45.86	.385	.656
	Post-test	45.21 (8.4)			
SGQ group (N=37)	Pre-test	43.59 (5.96)	45.17		
	Post-test	45.89 (7.31)			

Compensation strategy

Groups		Mean (s.d.)+	Adjusted Mean	*F*	*p*
cSGQ group (*N*=42)	Pre-test	12.78 (1.73)	13.35	.103	.469
	Post-test	13.21 (1.91)			
SGQ group (*N*=37)	Pre-test	13.4 (2.26)	13.66		
	Post-test	13.81 (2.27)			

Cognitive strategy

Groups		Mean (s.d.)+	Adjusted Mean	*F*	*p*
cSGQ group (*N*=42)	Pre-test	103.29 (17.25)	111.74	.241	.475
	Post-test	110.21 (17.12)			
SGQ group (*N*=37)	Pre-test	107.81 (16.63)	113.87		
	Post-test	115.56 (18.23)			

+ s.d.: standard deviation

3.3 The Perceived Cognitive Load

The results of using ANCOVA on the perceived cognitive load between the two groups were shown in Table 3. As for the perceived cognitive load between the two groups, no significant differences were found, $F = 0.414$, $p = .522$.

It was surprising that students in the cSGQ group didn't perceive more cognitive load compared with those in the SGQ group since the design of cSGQ learning task was comparatively complicated, and thus, participants in cSGQ group were expected to invest more mental effort into the learning tasks. The results regarding the perceived cognitive load showed that the innovative design of cSGQ was appropriate, in terms of cognitive challenging, for the learners in the present study.

Table 3. *Descriptive Statistics and the ANCOVA Result of the Perceived Cognitive Load*

Groups		Mean (s.d.)+	Adjusted Mean	*F*	*p*
cSGQ group (*N*=42)	Pre-test	36.9 (4.96)	36.69	.414	.522
	Post-test	33.37 (4.57)			
SGQ group (*N*=37)	Pre-test	34.72 (3.46)	37.8		
	Post-test	33.76 (3.64)			

+ s.d.: standard deviation

4. Conclusion

The present study adopted cSGQ learning tasks for EFL learners to cultivate their English proficiency and its effect as compared to SGQ was examined in terms of English learning performance, language learning strategy use and perceived cognitive load. Results showed that students in the cSGQ group outperformed those in SGQ group on English learning performance while no significant differences on the use of language learning strategies were found between the two groups. Also, no significant differences regarding the perceived cognitive load were found toward the two different designs of SGQ learning tasks. The present study contributes to the field's understanding of the various forces influencing English learning performance such as the designs of cSGQ learning tasks, the use of language learning strategies, and perceived cognitive load associated with cSGQ and SGQ learning activities. Regarding the design of cSGQ learning tasks for English learners, an innovative design of combining contextual learning with SGQ was devised and its effectiveness was attested by the present study to demonstrate its facilating effects on increasing the awareness on the linguistic clues and contextual information when using English.

Since the present study only focuses on the application of cSGQ into English learning, future research could investigate its application into other subjects to fully illustrate its learning potential for learners. Also, future studies could focus on other important outcomes of English learning, such as learning motivation and attitude toward learning English in light of its influential effects on the development of target language proficiency.

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Classification and Analysis of Learners' Proficiency Level in Marker Use based on Learning Logs

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Abstract: As the use of Learning Analytics has become widespread, real data has started to accumulate, and evaluation using such data has been practiced and shown to be effective globally. When data are used for evaluation, each teacher is required to combine and evaluate appropriate data according to the situation of each learner in their charge. However, teachers are not yet familiar with analyzing data; therefore, effective evaluation methods must be proposed and shared from Learning Analytics to encourage them to take the initiative in using data for evaluation. In this study, as an example of an evaluation method, we defined an evaluation index, "*proficiency level,*" for the use of markers on e-books using Zimmerman's Multilevel model. The data used were three months of study log data of 112 Japanese second-year junior high school students stored in a learning analysis platform called Learning and Evidence Analytics Framework. Subsequently, we focus on Active Reading (AR) English language learning which was held in the last week of that period. By comparing the reading speed of English text, Word Per Minutes, measured before and after Active Reading, we were able to clarify the differences in learning effects according to "*proficiency level*". This allowed us to confirm the validity of "*proficiency level*" as an evaluation index. In the future, we will work on the creation of a higher-order evaluation index from both data and theoretical perspectives, and it will enable teachers to support evaluation that responds to each learner.

Keywords: Learning Analytics, formative assessment, multilevel model

1. Introduction

With the recent digitalization of education, Learning Analytics has been put to practical use in real educational environments, and many types of learning log data have been accumulated (Sung, Chang, & Liu, 2016). "Learning analytics is the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs" (Ferguson, 2012, p.305).

Recently, these learning log data have begun to be used as learning evaluations (Faber, Luyten, & Visscher, 2017). This enables immediate evaluation that reflects each individual's situation in detail, which is difficult to achieve through test scores or peer evaluation (Sung et al., 2016). When log data are used for evaluation, each teacher is required to combine and evaluate appropriate data according to the situation of each learner in their charge. However, most evaluations in Japan today are still conducted on paper. Therefore, it is not easy for teachers to analyze simple features in existing log data, such as learning time or number of markers, and generate higher-order evaluation indices that reflect the learning situation. Consequently, it is necessary to share effective evaluation methods that utilize data among teachers. Learning Analytics will need to create and propose highly interpretable evaluation measures, correlated with learning outcomes, to support teachers.

Many of the features that have been focused on in Learning Analytics up to now were simple features that were obtained by summing raw log data. When these features were used for evaluation, it was necessary to correlate them with grades or regress them on external indicators, and then select those that were likely to be relevant to the evaluation. However, these features are not appropriate for teachers to use as evaluation indicators because of their low interpretability. In this study, we aimed to create a theoretically interpretable evaluation index.As a highly interpretive assessment, Zimmerman (2000) used a multilevel model to describe the proficiency of knowledge and skills acquired by learners through self-regulated learning (SRL). In this model, four levels of proficiency in SRL skills are assessed. We consider that the model could be applied similarly to evaluate SRL skills on e-book readers, such as the use of markers for highlighting. Formative assessment methods based on this theory have been tested in field settings and found to be effective in practice (Granberg, Palm & Palmberg, 2021).

To create a new higher-order assessment instrument, we focus on Active Reading (AR) English language learning, which requires the use of markers on the e-book reader. The students' use of markers in this class could be divided into multiple levels. We analyzed the logs of markers, which are simple features, to determine the *proficiency level* of marker use for each student based on four calculated student characteristics: *Performability*, *Applicability*, *Extensibility*, and *Continuity*. These were created according to a multilevel model. To examine the relationship between the obtained *proficiency levels* and learning effectiveness, we examine whether there are significant differences in reading speed in English (Word Per Minute, WPM) between the different *proficiency levels*. Although we focus on the use of markers in this study, in the future, we expect to generate higher-order evaluation indices for other functions to support evaluations that correspond to each student's learning. The research questions addressed in this study are as follows:

RQ1: For the four characteristics of Zimmerman's multilevel model, what value would be the criterion for determining whether it is high or low?
RQ2: Is marker *proficiency level* related to learning effectiveness?
RQ3: Compared to the number of markers, is *proficiency level* more indicative of a student's learning effectiveness?

2. Methods

2.1 Learning Evidence Analysis Framework

A Learning Evidence Analysis Framework (LEAF) system is a platform for using, managing, and collecting educational big data to support teachers' and students' learning in response to information and communication technologies (Ogata, Majumdar, Yang, & Warriem, 2022). Learning Management System (LMS) and e-book reader (BookRoll) logs are stored in the Learning Record Store (LRS) and used in the Learning Analytics Dashboard (LogPalette) to support teaching and learning.

Specifically, BookRoll allows students to view materials shared by teachers on the device. The student can highlight lines with the marker function and remove the highlighted lines. These interactions are saved in the log as 'ADD MARKER' and 'DELETE MARKER' in the LRS.

In the LEAF system, features (indicators) representing characteristics of learning, as shown in Table 1, are extracted from the data stored in the LRS. These indicators are used in LogPalette to support teaching and learning.

In this study, we focus on marker counts, obtained by summing the counts of 'ADD MARKER' and 'DELETE MARKER,' as an example of the simple features described in Section 1.

Table 1. *Example of Indicators*

Navigation Indicators	Annotating Indicators	Testing Indicators
Browsing time	Memo counts	Answered questions counts
Completion rate	Marker counts	Quiz completion rate
Bookmarks counts	Marker text	Accuracy rate at the first attempt
		Accuracy rate on recent attempts

2.2 Proposed Method

In this study, we extracted higher-order evaluation indices from marker counts, which are simple features. Based on the four levels in Zimmerman's (2000) multilevel model, we defined four characteristics that could be related to marker *proficiency level*, as shown in Table 2. The four levels in the multilevel model are classified by the teacher, who checks the students' efforts and determines which level they belong to. Therefore, to evaluate the levels using data, it is necessary to quantify the factors that are usually used by teachers when determining a student's level. The four characteristics in Table 2 are indicators that can be judged as being at the level of emulation if performability is high, self-control if applicability is high, self-regulation if extensibility and continuity are high, and self-regulation if extensibility and continuity are high. Observation is not included in the four characteristics because there is no corresponding data in the existing log data.

Based on the below definitions, the following characteristic variables were provided for each characteristic and quantified using log data.

- *Performability*: mean and standard deviation per minute of markers in classes with AR
- *Applicability*: mean per day and standard deviation of markers in classes other than AR
- *Extensibility*: mean and standard deviation per day of markers at home
- *Continuity*: percentage of daily change for all markers

Table 2. *Multilevel Model and Four Characteristics of the Proposed Proficiency Level*

Multilevel model (Zimmerman, 2000)		Four features proposed in this study	
1. Observation	Vicarious induction of skill from a proficient model	Not applicable	
2. Emulation	Imitative performance of the general pattern of the style of a model's skill with social assistance	Performability	Characteristics that perform when directed in a well-organized environment
3. Self-control	Independent display of the model's skill under structured conditions	Applicability	Characteristics of performing without being directed to do so in a well-organized environment
4. Self-regulation	Adaptive use of skill across changing personal and environmental conditions	Extensibility	Characteristics to be performed in an independent study setting
		Continuity	Sustained execution characteristics

For each of the quantified characteristics, the criteria for classifying each student into two groups, High and Low, were determined and classified. Based on the multilevel model, from the student groups, the *proficiency level* of the marker was classified into five levels as shown in Table 3. "-" denotes Low or High. We have divided self-regulation level in the multilevel model into two levels since it is given two characteristics.

Table 3. *Classification of Proficiency Levels by Four Characteristics*

Level	Performability	Applicability	Extensibility	Continuity
0	Low	Low	-	-
1	High	Low	-	-
2	-	High	Low	-
3	-	High	High	Low
4	-	High	High	High

2.3 *Context*

This study uses data from a Japanese junior high school that implements LEAF. The data included 13to 14-year-old students (n=112) who belonged to a class in which English AR was conducted using the BookRoll's marker function. In AR, students are asked to reread the English text they read when their WPM was first measured. Students highlight unfamiliar words in yellow and the words they consider important or as keywords in red. This teaches students how to use the markers as a kind of task strategy and helps them deepen their understanding of the text. The experimental class was held for three days (on June 27, 29, and 30). On the first day, AR was conducted, and WPM records were measured. On the second day, students deepened their understanding of the content through group activities and prepared for the following day's presentation. On the third day, the groups gave presentations on the contents of the previous day's group activities. The data were the markers' learning log data from April 1 to June 30, 2022, and the WPM records were measured before (June 27) and after (July 1) the AR. For the markers' log data, we used the markers' log data automatically stored in the LEAF system as described in Section 2.1 WPM was calculated from the number of words in the text and the reading time by measuring the time each student spent reading the English text by themselves. We then asked students to register their WPM on LogPallet and used only this recorded WPM for the analysis.

2.4 *Measuring Four Features and Proficiency Level*

The four characteristics in this study were generated for formative assessment. Since formative assessment must return a real-time evaluation of the student's current situation and learning behavior, it is necessary to calculate them using the student's latest data. For this reason, they were generated using the AR-recent data from June 24 to June 30. However, the criteria for determining the highs and lows of the four characteristics must be standardized and not variable from period to period or person to person. Therefore, we used data from April 1–June 30 to calculate the criteria. Moreover, we divided each student into two groups, high and low, based on the established criteria for the four AR-recent characteristics and determined the *proficiency level* of the marker for each student according to Table 3.

Since students are taught how to use markers in English reading comprehension exercises in AR, there should be a change in the use of markers in the AR-recent period. Therefore, the *proficiency level* of the AR-recent period should reflect the differences in the use of markers for each student.

2.5 *Data Analysis*

Three analyses were conducted in this study to investigate each research question:

- Analysis 1. Analysis for RQ1: "For each of the four characteristics of Zimmerman's multilevel model, what value is the criterion for determining whether it is high or low?"

The standard criteria of the four characteristics were determined to divide the markers into two groups, High and Low.

- Analysis 2. Analysis for RQ2: "Is marker *proficiency level* related to learning effectiveness?" There was a difference in WPM measured before and after AR, and the change in value is thought to be related to learning before and after AR. Therefore, we used markers' *proficiency* *level* as a value to quantify differences in learning by each student, and students were divided into two groups according to their *proficiency level*. We visualized the differences in the distribution of WPM obtained before and after AR between the groups. To confirm whether there is a significant difference in WPM between the two *proficiency levels*, a Mann-Whitney u-test between the two groups of High and Low students was conducted.

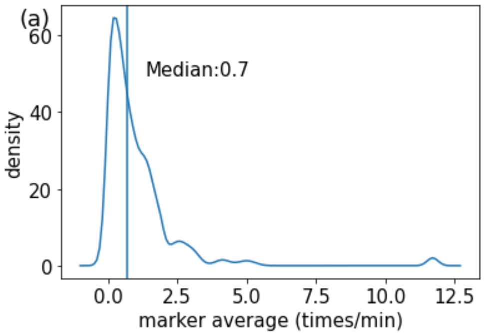
- Analysis 3. Analysis for RQ3: "Compared to the number of markers, is the *proficiency level* more indicative of a student's learning effectiveness?"

For each *proficiency level*, we visualized the distribution of WPM scores obtained before and after AR. We also visualized the distribution of WPM concerning the number of markers during the entire period for comparison with the distribution by *proficiency level*. We used analysis of variance to confirm whether WPM before and after AR changes with proficiency level or with the number of markers, respectively.

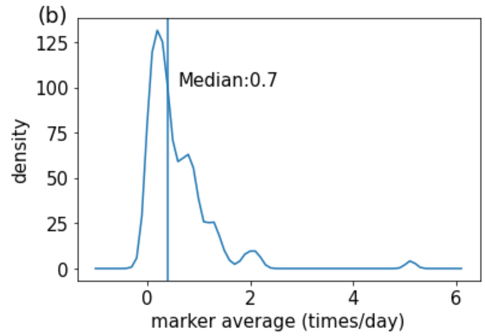
3. Result and Discussion

3.1 Results of RQ1

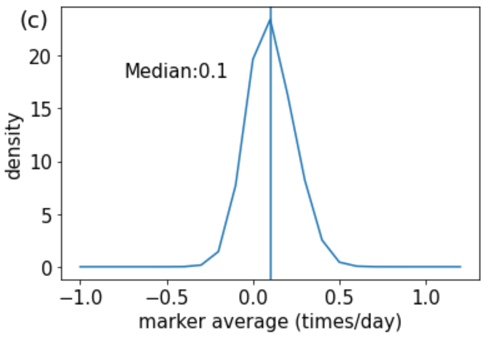
From the log data of students' markers in the three classes in which AR was conducted, we extracted features related to the four characteristics (Figure 1).



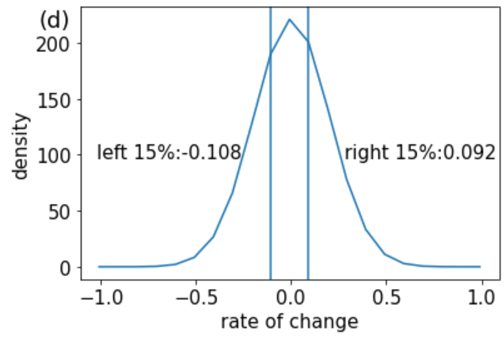
(a) Mean distribution of markers per minute in Active Reading (*Performativity*).



(b) Average distribution of markers per day in classes other than Active Reading (*Applicability*).



(c) Mean distribution of markers per day at home (*Extensibility*).



(d) Distribution of the percentage of daily changes for all markers (*Continuity*).

Figure 1. Distribution of the four characteristics and criteria for marker use.

We defined *performability*, *applicability*, and *extensibility* as the mean distribution of markers by the superposition of the normal distribution created from each student's mean and standard deviation. *Continuity* was defined as the distribution of the percentage of change by superposition of the normal distribution created from each student's percentage of change and standard deviation 0.1.

Because graphs (a), (b), and (c) in Figure 1 are all skewed to the right and outliers exist, we used the median as the standard for *performability*, *applicability*, and *extensibility*. However, for (d), we classified High and Low based on the 15% interval from the median. Regarding the number of people classified, we determined the standard. Thus, *performativity* is considered high if it is used approximately 0.7 times per minute during AR, *applicability* is considered high if it is used approximately 0.7 times per day at school, *extensibility* is considered high if it is used more than 0.1 times per day at home, and *continuity* is considered high if the rate of change is between -0.108 and 0.092 in the last week.

3.2 Results of RQ2

Figure 2 shows the distribution of WPM calculated before and after AR for each group after dividing the *proficiency level* into two groups, High and Low, from the 24th to 30th of June.

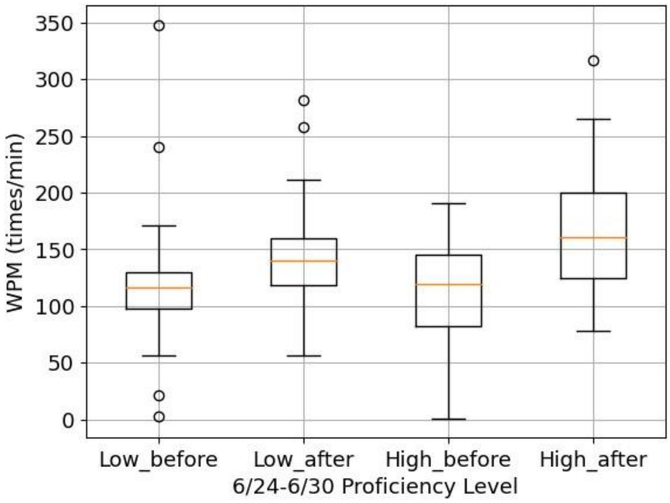


Figure 2. Distribution of words per minute before and after Active Reading for the two groups regarding *proficiency level* from June 24th to 30th.

Next, to confirm that the High group had higher WPM than the Low group, the WPM scores were compared between the two groups. First, the normality of the data for each group was checked using the Shapiro-Wilk test. Since normality was not found, we performed a Mann-Whitney u-test on the two groups with no correspondence between Low_before and High_before and Low_after and High_after to see if they indicated a link between WPM before and after AR, respectively. The results showed that $p=.62$ for WPM before AR and $p=.03$ for WPM after AR. Assuming a significance level of 5%, there was a significant difference in medians between the groups after AR, while there was no significant difference between the groups before AR. Therefore, it appears that students with higher *proficiency levels* improved their WPM more than those with lower *proficiency levels*. From this, we infer that displaying marker proficiency level to students will have the effect of encouraging marker use and further improving WPM.

3.3 Results of RQ3

Two multiple regression analyses were conducted to show that *proficiency level* is more indicative of a student's learning effectiveness than the number of markers. The first was a regression including the WPM values on the number of markers for each student, a dummy variable indicating whether the value was before or after WPM, and their intersection terms as explanatory variables. Figure 3 shows the regression line and the distributions of WPM calculated before and after AR concerning the number of markers. The second was a regression including the WPM values on the *proficiency level* for each student, a dummy variable indicating whether the value was before or after WPM, and their intersection terms as explanatory variables. Figure 4 shows the regression line and distributions of WPM calculated before and after AR for each *proficiency level*.

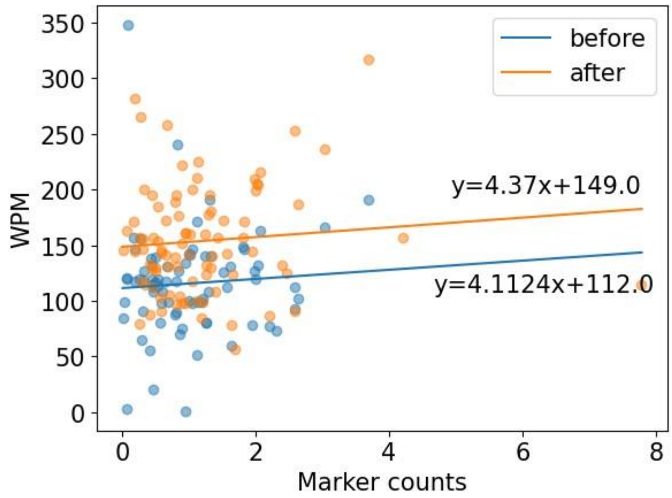


Figure 3. Distribution of words per minute before and after Active Reading concerning the number of markers from April 1 to June 30.

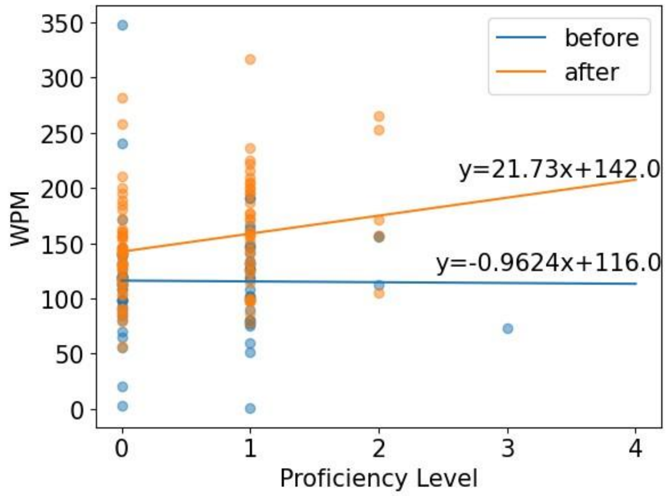


Figure 4. Distribution of words per minute before and after Active Reading concerning *proficiency level* from June 24 to 30.

For the two factors used in the regression in Figure 3 and their interactions, we performed an analysis of variance with these as factors: for WPM, there was no significant difference in the effect of the number of markers (p=.75). Similarly, no significant difference was found in the effect of the interaction between the dummy variable indicating pre- and post-WPM and the marker (p=.82). From this, it appears that there is no association between the number of markers and WPM. Conversely, for the two factors used in the regression in Figure 4 and their interactions, we performed an analysis of variance with these as factors: for WPM, there was no significant difference in the effect of proficiency level (p=.91). However, the effect of the interaction of the marker with the dummy variable indicating that it is the WPM before and after is p=.06, which means that a significant difference is found when the significance level is set at 10%. From this, it appears that proficiency level is not directly related to WPM values, but that proficiency level is related to WPM growth. This suggests that *proficiency level* captures the learning effect of students in more detail than the simple indicator of number of markers. Therefore, assessment by marker proficiency level would reflect the diversity of student efforts and would allow for accurate feedback tailored to the student's situation.

4. Conclusion

In this study, we quantified the degree of *proficiency levels* in marker use from Zimmerman's multilevel model as an example of how to create a higher-order evaluation index. To examine whether the *proficiency level* of the created markers can express learning effects better than the simple feature of the number of markers, we visualized and clarified the difference between the distribution by *proficiency level* and the distribution by the number of markers for WPM. Subsequently, analysis of variance was conducted on WPM obtained before and after AR in terms of proficiency level or number of markers, and no significant difference was shown by number of markers before and after AR, but there was a significant difference in proficiency level. The results showed that the *proficiency level* reflected the learning effect better than the number of markers. In addition, we examined whether differences in *proficiency levels* were indeed related to learning effectiveness and found that students with higher *proficiency levels* showed higher growth in their WPM. From this result, we confirm that the use of *proficiency levels* as an evaluation index can enhance the interpretability of the features and enable evaluation that is more responsive to the student's learning.

However, this study has some limitations. In this study, the *proficiency level* of markers was determined using Zimmerman's multilevel model, which could be applied to a class that teaches the use of AR markers. However, it is not always possible to determine whether the teacher encouraged the use of other functions in the class, other than markers, and it is difficult to calculate the *proficiency level* in the same way. Additionally, the *proficiency levels* of the markers alone are not sufficient to represent the diversity of learning. Therefore, it is necessary to calculate higher-order features for simple features extracted from the logs of other functions in BookRoll and LMS (Moodle), as shown in Table 1. However, as mentioned above, we do not know if the multilevel model can be applied. Therefore, it is necessary to devise a new theory to apply the multilevel model and to consider other models in future research.

As evaluation indicators are expanded in the future, teachers will be able to select from a wider range of evaluation indicators and benefit from a form of evaluation that responds to a variety of learning styles.

Acknowledgements

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Nudge Messages for E-Learning Engagement and Student's Personality Traits: Effects and Implication for Personalization

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Abstract: The educational use of nudges has received much attention. However, individually optimized nudge interventions have not been well studied. In order to determine which nudge messages are effective for learners with what profiles based on personality inventories, we examined two nudge message interventions that promote the use of learning systems during the summer vacation period to see if they promote use. During summer vacation, students were divided into two groups and sent different types of nudges to each. One is a deadline notification: a notification with the number of days remaining in the summer vacation, and the other is a peer notification: a notification of other students' achievements. We analyzed the frequency of each student's reaction to the notification based on their personality traits. The results show that there was a significant negative correlation between frequency of response to peer notifications and conscientiousness (R=-0.43), and a slight positive correlation between frequency of response to deadline notifications and conscientiousness (R=0.32), peer notifications and neuroticism (R=-0.35) and peer notifications and openness to experience (R=-0.31). These results suggest the possibility of individually optimized nudge interventions by personality.

Keywords: Nudge, message intervention, Big Five Inventory, educational data mining, learning analytics

1. Introduction

The educational use of nudges has received much attention (Damgaard & Nielsen, 2018). The introduction of nudges in education studies is called a framing intervention, which involves deadline-type nudges and peer-type ones (Damgaard & Nielsen, 2018). Some studies using nudge interventions insist on the improvement of students' performance (O'connell & Lang, 2018; Motz, Mallon, & Quick, 2020). However, there are no mentions of peer evaluations while there are of deadline ones. In order to determine which nudge messages are effective for learners with what profiles, we examined two nudge message interventions that promote the use of learning systems during the summer vacation period to see if they are effective. Big Five Inventories have been studied (John, Donahue, & Kentle, 1991), and it is now one of the most popular methods for estimating people's personalities. This study examines the relationship between individual personality and nudge message content according to Big Five Inventories. In particular, we try to answer the following research question:

RQ: To what extent do different types of nudge messages affect students' engagement based on personality type?

2. Related Works

Nudge is a behavioral economics term, and the purpose of its policy is stated as "alter[ing] people's behaviors in a predictable way without forbidding any options or significantly changing their economic incentives" (Thaler & Sunstein, 2008). In education studies, the use of nudges has received much attention. A study suggested that students do not mind receiving nudges more often if they perceive the nudges to be useful to them. (Gatare et al., 2021).

The introduction of nudges in education studies is called a framing intervention. Even small changes in the framing of information have the potential to alter behavior and eliminate biases due to cognitive and attentional limitations (Damgaard & Nielsen, 2018). One type of framing intervention is the deadline type. Examples of deadlines are tests and examinations, which are naturally created deadlines, and the more these are, the better students perform (O'Donoghue & Rabin, 1999). Another type of nudge is peer group manipulation, which seeks to facilitate peer-to-peer work. It can be useful in enhancing a sense of social belonging, compelling the creation of social norms for striving, and improving and acquiring skills through partnerships. (Carrell, Sacerdote, & West, 2013; Rogers & Feller, 2016; Papay, Taylor, Tyler, & Laski, 2020).

Zavaleta-Bernuy et al. (2022) showed that reminder messages are useful for some students to complete their homework by its deadline. A study with a closer examination of time periods and durations revealed two distinct patterns that could explain observed increases and found the possibility that low-cost behavioral interventions could be implemented to improve student performance. (O'connell & Lang, 2018). That is, those who received reminders engaged in studying slightly longer on weekends and started that about a few hours earlier on weekdays. Another study showed that assignment submission rates improved with automated nudge reminders by the time rather than supervisors sending out notifications all at once (Motz et al., 2020).

However, individually optimized nudge interventions have not been well studied, and there is no mention of peer evaluations while there are deadline ones. We suppose there could be some variety of nudge messages that take into account the student's personality, and different nudges affect differently on students' quiz-tackling efforts. This study focused on the relationship between individual personality and the content of notifications to determine what types of nudge message interventions would be effective for individuals with these personalities.

A common way to measure personalities is personality inventories. They are a set of questionnaires designed to reveal the personality of a subject in psychology. Big Five Inventory (John et al., 1991) is a well-known method for revealing people's personalities, which is the inventory for classifying people's personalities into five categories: Openness to experience, Extraversion, Agreeableness, Conscientiousness, and Neuroticism, hereinafter referred to as O, A, C, E, N. This taxonomy is a method that has gained a lot of popularity, and there are examples of research on the assignment of appropriate adjectives to these five categories (Hofstee & Raad, 1992; Johnson & Ostendorf, 1993; Goldberg, 1992). In this research, we use the Big Five Inventory to decide each student's personality.

3. Methodology

3.1 Participants and dataset

We conducted the study at a high school in Japan. The study population consisted of 167 students in four classes of first-year high school students. In this experiment, 84 participants from two classes were assigned to Group 1, and 83 participants from two classes were assigned to Group 2.

To estimate students' personalities we used a Japanese version of a questionnaire survey about their personal traits (Murakami, & Murakami, 1997) to measure each of them on a 12-point scale for O, A, C, E, and N respectively (John et al., 1991). The Big Five exam consists of 70 questions, 60 of which are in the form of applicable/not-applicable questions related to one of the five personalities. Students answer these questions with yes or no. Using the student's answers, the score of each personality of each student is calculated by taking the sum of each item.

We collected the data during the summer vacation over the period of July 20 - August 22, 2021. In this period, the students should work on 54 or 58 math quizzes as their homework using a recommender system which is called the explainable recommender system (AI recommender system) (Takami, Dai, Flanagan, & Ogata, 2021, 2022). The system can recommend appropriate questions to students in an explainable way based on their learning logs. They use a learning platform system called moodle (Dougiamas & Taylor, 2002), from which they enter an eBook system called BookRoll (Ogata et al., 2015) to work on assignments. When they log in to Moodle, they are presented with a screen of notifications that they have received, as shown in Figure 1. The students use the BookRoll eBook system to work on their math assignments. It collects learning log data within the LEAF Learning Analytics framework (Flanagan & Ogata, 2018). Every three days (except between Jul. 24 and Jul. 26) at around 22:00, the system sent notifications to students who had not logged in an AI recommender system within 3 days. The deadline type notifications were sent to students in Group 1 and peer type notifications to students in Group 2. Table 1 shows the English translation of the notifications sent to students during the summer vacation.

We collected data from a total of 66 students, 36 from Group 1 and 30 from Group 2, who logged into Moodle during the summer vacation, out of a total of 167 students in Group 1 and Group 2 mentioned above. The 66 students made a total of 198 accesses to the AI recommender system and sent a total of 629 notifications to them.

Table 1. *Contents of a deadline/peer type notification*

Type	Content of notification
Deadline	You don't seem to have logged into an AI recommender system in the last 3 days. The 15 days of the summer vacation period have passed. The summer vacation will end in 16 days. Let's proceed with learning more efficiently with the AI recommendation function.
Peer	You don't seem to have logged into an AI recommender system in the last 3 days. In the last 3 days, 29 people in the class logged in and learned 122 quizzes. You have 50 quizzes left. Let's proceed with learning more efficiently with the AI recommendation function.

Figure 1. Screenshots of message notification in Moodle system

3.2 Data preprocess and prediction

For data analysis, we used the LassoCV model (Tibshirani, 2011) from sklearn.linear_model package, a Python package for machine learning (Pedregosa et al., 2011, available at https://scikit-learn.org/stable/modules/linear_model.html). Lasso is a widely used research model in variable selection. Various methods have been proposed (Freijeiro-González, Febrero-Bande, & González-Manteiga, 2022), and it is also used in Big Five analysis (Tanaka, Nihonsugi, Ohtake, & Haruno, 2021). It performs variable selection and regularization that foster accurate prediction and easy comprehension of the created statistical models. LassoCV can also cross-validate multiple parameters and automatically set the most accurate ones (Friedman, Hastie, & Tibshirani, 2010).

Lasso can deal with a large dimensionality of explanatory variables caused by the variable interaction terms, and it estimates the weights of many non-valid explanatory variables to be zero. Therefore, it can be said that a non-zero weight implies a large contribution.

4. Result

4.1 Reaction rate

To test the effectiveness of the notifications, we measured the reaction rate of students to the notifications as the percentage of notifications received by a student for which there are logs that the student worked on the quiz before receiving the next notification. For example, as shown in Figure 2, the user received a total of 7 notifications, three of which (July 24, July 29, and August 16 indicated in blue) were ones with a record of quiz effort in the period immediately following, so reaction rate is 3/7 ~ 0.43. A higher reaction rate indicates that a higher proportion of those students worked on the problem after reading the message, so it can be said that the higher this value is, the more effective the message is.

Figure 3 shows the relationship between reaction rate and the quiz-tackling operation for each type, which consist of the number of logging in the AI recommender system. Table 2 shows the results of the Pearson correlation analysis. As can be seen from the analysis results, there is a positive correlation between reaction rate and the number of operations, each of which is significant. This means that the higher the reaction rate is, the more times the students work on the quizzes. Note that no such person engaged a lot but missed only one message out of one (reaction rate is 0).

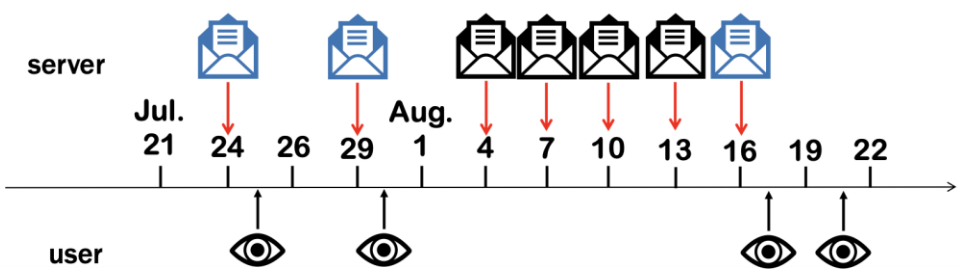

Figure 2. An example of a user’s action and the server sending messages

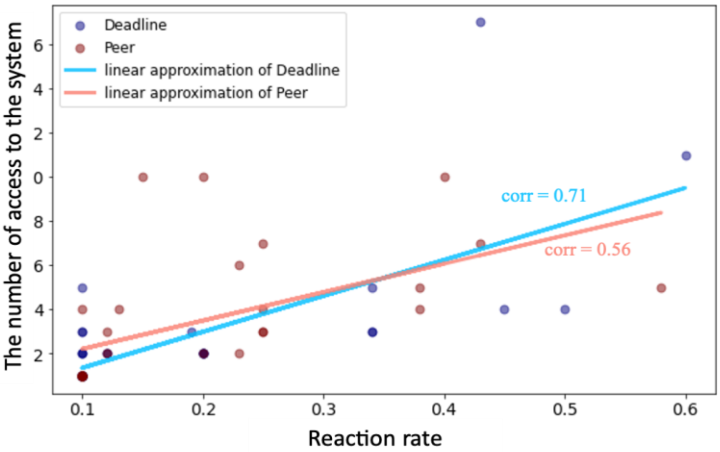

Figure 3. Relationship between the number of access to the system and reaction rate

Table 2. *Correlation analysis between reaction rate and the number of access to the system*

Message type	Pearson correlation coefficient	*p-value*
Deadline	0.71	< 0.001***
Peer	0.56	0.0013***

*** $p < 0.01$

4.2 Relationship between personal traits and reaction rate

We used LassoCV, which was a well-used analysis of personality traits (Tanaka et al., 2021) to find out which personality traits were significantly correlated with the reaction rate. We used 20% of the data as test data and trained using 5-fold cross-validation. We used grid search to determine the optimal regularization parameter α in the range $10^{-6} \leq \alpha \leq 10^{2}$.

Table 3 shows the standardized coefficient values for each personality trait and the optimal α, and Figure 4 visualizes the results of standardized coefficients. As a result, we found that there is a tendency for a positive correlation with C for the deadline type, and a negative correlation with O, C, and N for the peer type. There is a slight negative correlation with E for the peer type.

Table 3. *Obtained values using Lasso*

Notification Type	Standardized coefficients					α
	O	A	C	E	N	
Deadline	0	0	0.0173	0	0	0.0251
Peer	–0.0212	0	–0.0412	–0.0026	–0.0362	0.0100

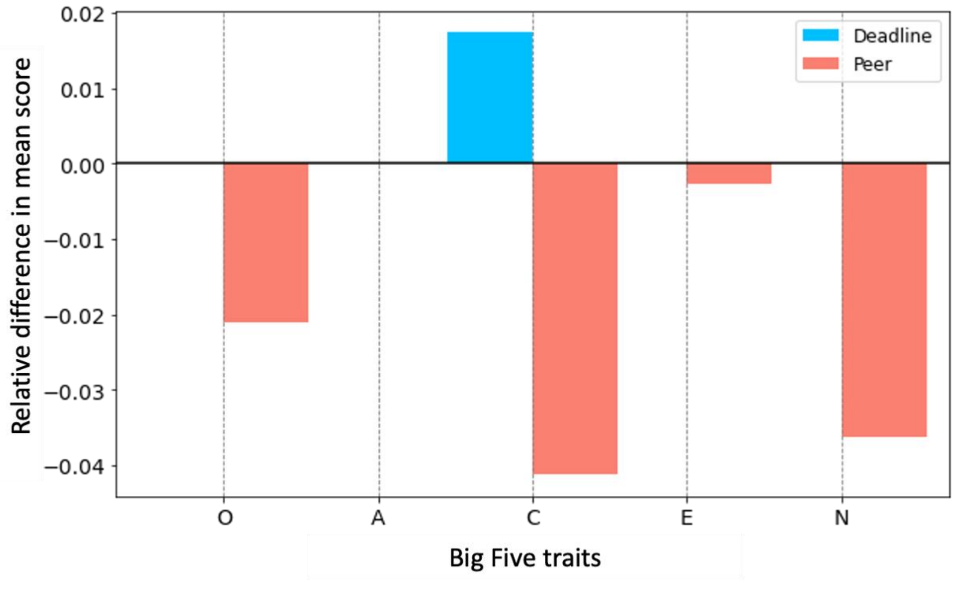

Figure 4. Standardized coefficients obtained using lasso

Table 4 shows the correlation coefficients and p-values for the relation between the reaction rate and the C score in the deadline type or the C, O, N or E score in the peer type, which has a non-zero relative difference in Lasso analysis. Figure 5 shows the relationship between the reaction rate and the C score, and Figure 6 shows the relationship between the reaction rate and the O, N or E score. For visualization using box plots with respect to the personal traits scores, the 33rd, and 66th percentiles were used to classify the respondents into three groups, with Low, Middle, and High in descending order from lowest to highest scores.

There was a significant negative correlation between the C score and reaction rate for peer notifications. This result suggests that the lower the C score, the more susceptible to peer notifications.

For the other relationship, there were significant tendencies in correlations. What these suggest is as follows: the higher the C score, the more susceptible to deadline notifications, and the lower the O or N score, the more susceptible to peer notifications. There is no significant correlation between E score and reaction rate for peer notifications.

According to previous research on personal traits using the Big Five, adjectives used to describe people with a tendency toward conscientiousness include "punctual" (Johnson & Ostendorf, 1993) or "systematic" (Hofstee & Raad, 1992). From these studies, it can be concluded that sending notifications to students with a tendency toward conscientiousness can be effective for reasons such as time or school systems. On the other hand, people with low conscientiousness, described by words such as "careless" (Johnson & Ostendorf, 1993), are generally more likely to implement a problem without examining it closely, so nudges that notice peer engagement are good for their study planning. Therefore, notifications that others were working on the problem are considered to be effective. People with low values of "openness to experience" are described by words such as "unreflective" (Goldberg, 1992), so it can be considered that knowing how others are tackling a problem could give them an opportunity to study that they were not aware of themselves. People with low values of neuroticism are described by words such as "envious" or "emotional" (Goldberg, 1992), so they are considered to be more susceptible to notifications that tell them how others are dealing with quizzes. Table 4. *Correlation analysis between various traits and reaction rate*

Type	Personal traits	Correlation coefficient	*p-value*
Peer	C	–0.43	0.0173 **
Deadline	C	0.32	0.0585 *
Peer	O	–0.35	0.0602 *
Peer	N	–0.31	0.0910 *
Peer	E	–0.26	0.1711

** $p < 0.05$, * $p < 0.1$

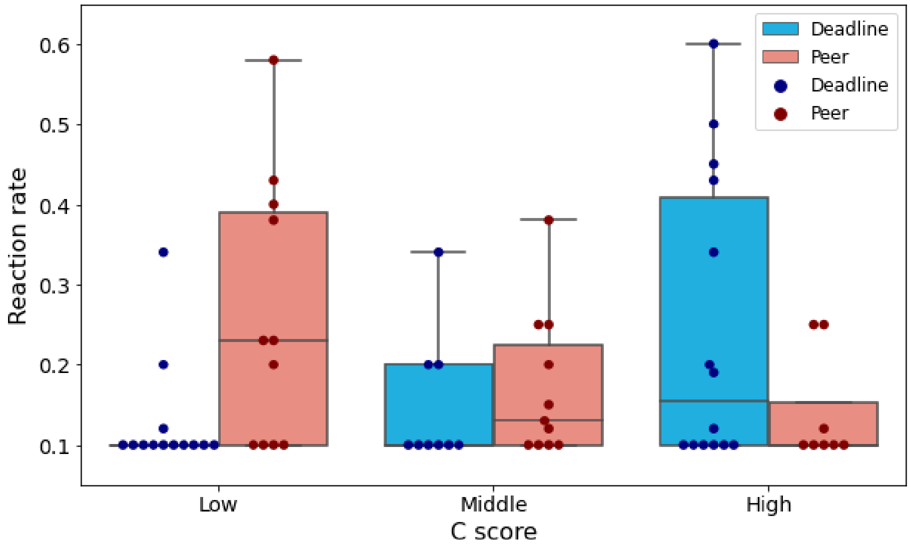

Figure 5. Relationship between reaction rate and C score for both types of notification

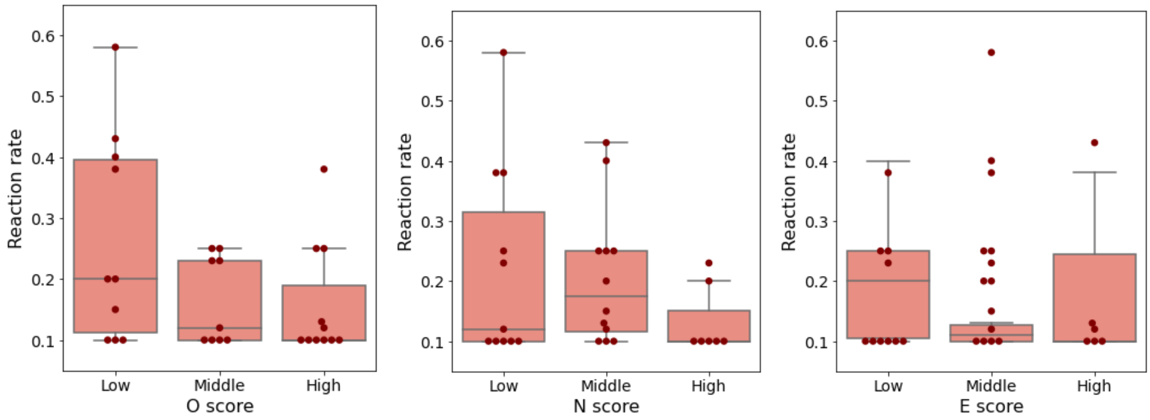

Figure 6. Relationship between reaction rate and O, N, or E score for peer notification

5. Limitations and future research

There are some limitations to this study. First, this study is not a study of individually optimized interventions, but we showed that different nudge messages had different effects on different personalities, which is a key finding of individually optimized interventions based on personality traits. For future research, it is necessary to develop a system that automatically optimizes and sends messages with individually optimized nudges based on personalities and verifies whether it is actually more effective than existing ones. There is also room to examine the effects of various other nudges (Damgaard & Nielsen, 2018) on their personalities, such as goal setting (Goal setting nudge) whereby students set their own goals and nudges that work on students' parents. Furthermore, it remains to be investigated whether nudge messages can improve the degree to which students do their regular homework during the semester, not during the summer vacation. Another limitation of the Big Five Inventory, asking students nearly 70 questions about the Big Five Inventory to K-12 students would be burdensome and needs to be a way to reduce the burden of conducting them such as predicting personality traits from the learning logs (Takami, 2022).

6. Conclusion

In this study, we tested what message content would have an effect on students of any personality. First, we divided the subject students into two groups, sending deadline-type notifications to one group and peer-type notifications to the other. Next, using Lasso regression, we determined which personalities correlated with the effectiveness of the notifications. Finally, for each of the personalities that seemed to correlate with effectiveness, we examined the correlation with the response rate of the notification. The results show that there was a significant negative correlation between frequency of response to notifications and conscientiousness for peer notifications (R=-0.43), a slight positive correlation between frequency of response to notifications and conscientiousness for deadline notifications (R=0.32), neuroticism for peer notifications (R=-0.35) and openness to experience for peer notifications (R=-0.31). These results suggest the possibility of individually optimized nudge interventions altering learners' behaviors by personality.

Acknowledgments

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Relating Student Performance and Procrastination Behavior in Online Discussion Forums

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Abstract: Procrastination is a behavioral feature in which a person chooses to delay a task or a decision. Academic procrastination is the tendency to postpone school-related obligations despite known negative consequences. In this paper, we examine how procrastination manifests in online discussion forum participation in a university in the Philippines during the COVID-19 pandemic. We visualize how high- and low-performing students differ in the rate at which they respond to discussion forum prompts. We also make use of association rule mining in order to determine which student behaviors are antecedents of procrastination. We find that most high-performing students tend to respond to discussion forum prompts much earlier than most low-performing students. This implies that they procrastinate less. We also found that making initial accesses or posts later or no graded posts at all makes the student at risk for poor performance.

Keywords: Procrastination, Online Learning, Philippines, COVID-19

1. Introduction

Milgram (1998 in Moonaghi & Beydokhti, 2017) defines procrastination as a behavioral feature in which a person chooses to delay a task or a decision. When applied in an educational context, academic procrastination is the tendency to postpone school-related obligations, despite known or anticipated negative consequences. There are many reasons why students may choose to procrastinate. The choice may stem from a form of sensation-seeking in which students need to work under greater time pressure. They may be distracted by media or games. They may choose to socialize instead of work. They may lack the ability to manage their time or they may feel demotivated. Regardless of the reason, studies have found that procrastination's effects are always negative.

In this paper, we discuss how procrastination manifests in online discussion forums conducted in tertiary-level classes during the COVID-19 pandemic. Specifically, we visualize how high- and low-performing students in terms of grades differ in the rate at which they respond to discussion forum prompts and we look for association rules that may point to the antecedents or precursors of procrastination. Studies of this kind may contribute to the development of criteria to detect student procrastination and can help in the design of educational interventions to mitigate this behavior. The research questions for this study are as follows:

1. How long does it take for high- and low-performing students to make an initial access to a course discussion forum, whether graded or ungraded?
2. How long does it take for high- and low-performing students to make an initial post to a course discussion forum, whether graded or ungraded?
3. What is the relationship between the average days elapsed to initial access or post and the performance (estimated overall average grade) of a student?

2. Review of Related Literature

Prior literature has found associations between procrastination and poor learning outcomes in general. Studies that investigate student participation and performance in online classes provide corroborating evidence for these conclusions. In what claims to be the first empirical study for the relationship between procrastination and participation in online discussion forums, Michinov and colleagues (2011) found that high procrastinators were less successful than low procrastinators partly due to the former's lack of participation in online discussion forums. Jones and Blankenship (2021) investigated the relationship between submission time and academic grades before, on, and after a submission. They found that earlier submission dates tend to be positively related with higher grades.

Studies on student participation during the COVID-19 pandemic continued to provide evidence that procrastination negatively correlates with learning. They also provided evidence of the relationship between procrastination and other characteristics and traits that in turn have implications on how well students cope with their academics. Procrastination was less common, for example, among students who were intrinsically motivated and who were capable of self-regulated learning strategies such as time management and goal-setting (Pelikan, Lüftenegger, Holzer, Korlat, Spiel, & Schober, 2021). Procrastination was more common among students who perceived themselves as having lower competence. Students with high levels of social support from roommates, partners, and family tended to report lower levels of academic procrastination (Liimatta, 2021). Students who were present-biased, i.e. had a preference for a small reward now rather than a large reward later, procrastinated possibly because studying with peers kept them focused and committed (De Paola, Gioia, & Scoppa, 2022). In the absence of such social pressures, they were more easily distracted by social media, games, and other applications.

Researchers use a number of learning analytics methods to arrive at these relationships. In the study conducted by Goda et al. (2014), the aim was to extract learning behavioral types in e-learning and discover the relationships between the different learning types and learning outcomes. After determining the seven learning behavioral types (including procrastination) based on the weekly completion rates of the learning materials and weekly-accumulated completion rates in the first phase, the researchers proceeded with correlating these learner behavior types with learning performance indicators (in this case, the scores of TOEIC-IP) using ANOVA (Goda, Yamada, Kato, Matsuda, Saito, & Miyagawa, 2014). The results showed that students who fall into the learning habit or chevron types significantly scored higher on the TOEIC-IP than the procrastination type (Goda et al., 2014).

In another study conducted by Cerezo et al. (2017), the proponents used Moodle logs to extract variables related to procrastination including those related to the number of days the students wait to check each assignment, task, forum subject, and theoretical content, and those related to the number of days that they took to hand in their task and post their opinion (Cerezo, Esteban, Sánchez-Santillán, & Núñez, 2017). These characteristics for procrastination were chosen as the proponents wanted to observe "the students' behavioral patterns before the homework deadline and not solely considering late or absent submissions" (Cerezo et al., 2017). Class Association Rules (Predictive Apriori) were then applied to the data after it was discretized using equal-width for the antecedent variables and a custom method based on the Spanish grading system for the performance (class/consequent variable) (Cerezo et al., 2017). The resulting association rules showed that, in general, "evidence of procrastination in the antecedents leads to poor performance, and signs of successful time management end up with satisfactory achievement" (Cerezo et al., 2017).

This study follows the methods used by Cerezo and colleagues (2017) in order to determine how high- and low-performers from a university in the Philippines differ in their procrastination behavior. Furthermore, we use association rule mining to find the antecedents of procrastination, increasing the likelihood of early detection.

3. Methodology

3.1 Description of Dataset

The dataset consisted of Canvas log files collected from a university in Quezon City, Metro Manila, Philippines during the first semester of Academic Year (AY) 2021-2022 (August 26, 2021 to December 18, 2021) (De Leon, 2021). The process of selecting the logs to analyze was as follows:

- The logs should come from a course discussion forum topic which has a definite classification of whether it is graded or not.

- The logs, whether posts or accesses, are generated by students whose overall grades can be estimated from 6 or more enrolled courses (ACU International, 2021; Ateneo de Manila University, 2021).
- The logs should come from a course wherein the list of students could be determined from the asset accessed logs, since data for the list of students enrolled in a course is not readily available from the Canvas log files.
- The logs occurred between August 26, 2021 to December 18, 2021 (in UTC).

3.2 Data Preprocessing

The course discussion forum log files are first grouped according to whether it is an Access or a Post. Accesses are considered in addition to Posts in order to account for the possibility of "lurkers" (i.e. those who just access the course discussion forums but not to post) (Guzdial & Carroll, 2002; Nandi, Hamilton, Harland, & Warburton, 2011; Salmon, 2003). For each of the categories, the data is split based on whether the course discussion forum topic each log pertains to is graded or ungraded. There was a total of 3,956,866 course discussion forum access logs and 206,767 course discussion forum post logs analyzed, of which 1,311,437 logs and 83,923 logs are accesses and posts, respectively, to graded course discussion forums. Hence, there are a total of four analyses that were made: Accesses-Ungraded, Accesses-Graded, Posts-Ungraded, and Posts-Graded.

For each of the analyses, the data preprocessing procedure starts by aggregating and getting the earliest date of post/access per course ID, course discussion topic ID, and user ID, which is then subtracted to the overall earliest date of post/access per course ID and course discussion topic ID. In order to accommodate for the possibility that the student may not have posted at all in a particular course discussion forum topic, an imputation of values was done wherein per course, a cross-product of the complete list of topics and students was performed and then merged with the observed data to generate a complete dataset, with the students who did not post on a particular course discussion topic given a value of 115 for the days elapsed from the first post/access for that course discussion topic. 115 is the total number of days comprising the 1st Semester AY 2021-2022 period, and since the first day, August 26, 2021, is marked as Day 0, Day 115 pertains to the date of December 19, 2021, the day after the last day of 1st Semester AY 2021-2022 (December 18, 2021).

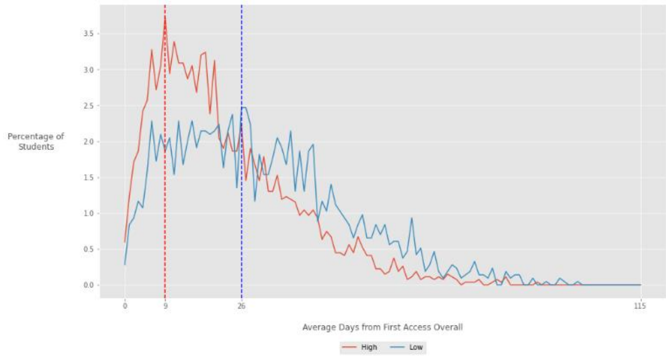
3.3 Statistical Analysis

For each of the four analyses, two sub-analyses are made. The "Overall" sub-analysis involves taking the average of the days elapsed from the date of the first post/access for each user regardless of the course, and then getting the performance ranking of each user (High if estimated overall average grade is greater than or equal to 87% or Low otherwise) ("Academic Grading in the Philippines", 2022). A total of 2,688 high-performing students and 2,148 low-performing students were included in the Accesses-Ungraded and Posts-Ungraded analyses, of which 2,657 high-performing students and 2,116 low-performing students were part of the Accesses-Graded analysis, and of which 2,655 high-performing students and 2,113 low-performing students are included in the Posts-Graded analysis. The percentage of the total number of students who made a post/access per ranking is then obtained per days elapsed since the initial post/access. On the other hand, the "Per Course" sub-analysis is similar except that the average of the days elapsed from the date of the first post/access for each user is first calculated per course, and then the values per course are then averaged together per user. For both of the two sub-analyses, another dataset is generated by bucketing the averaged days elapsed from initial post/access per user. These resulting datasets (8 in total, each pertaining to a particular Posts/Accesses-Graded/Ungraded-Overall/Per Course combination, with a total of 4,768 students included) are then used for the association rules analysis procedure using the Predictive Apriori Algorithm in Weka 3.8.6, with the overall performance of the student as the consequent variable (Cerezo et al., 2017). Two association rules analysis results were generated, one for the "Overall" sub-analysis and another for the "Per Course" sub-analysis.

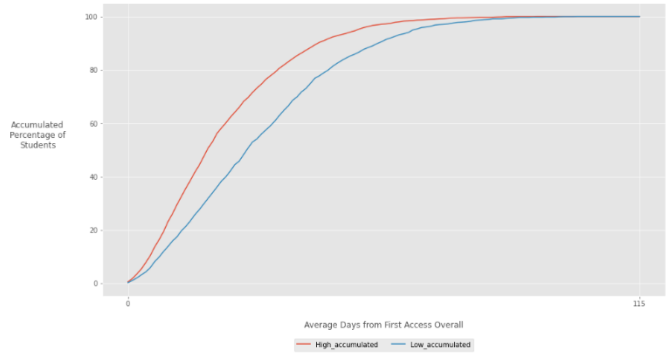
4. Results and Discussion

4.1 Accesses-Ungraded

In both Figures 1a and 2a, it could be clearly seen that the majority of the high-performing students begin accessing the ungraded course discussion forums earlier than their low-performing counterparts. In Figure 1a, approximately 3.72% of the high-performing students begin accessing the ungraded course discussion forums 9 days from the initial access overall while around 2.47% of the low-performing students begin accessing 26 days from the initial access overall. In Figure 2a, on a per course perspective, approximately 3.57% of the high-performing students begin accessing the course discussion forums 14 days from the initial access, while around 2.61% of the low-performing students begin accessing the course discussion forum 20 days from the initial access. Also, as the days elapsed from the initial access increases, the percentage of low-performing students begin to outnumber the percentage of high-performing students. In the accumulated percentage graphs shown in Figures 1b and 2b, the high-performing students reach the peak first before the low-performing students.

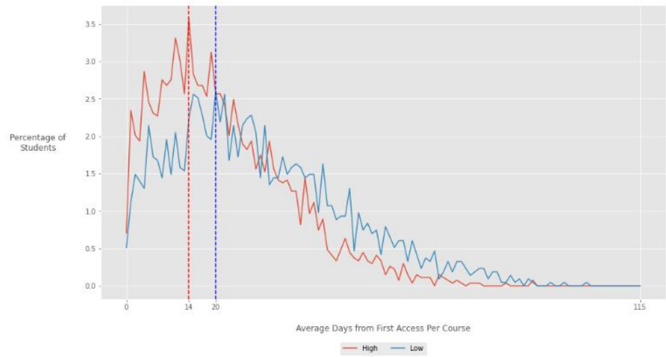


a. Raw Percentage

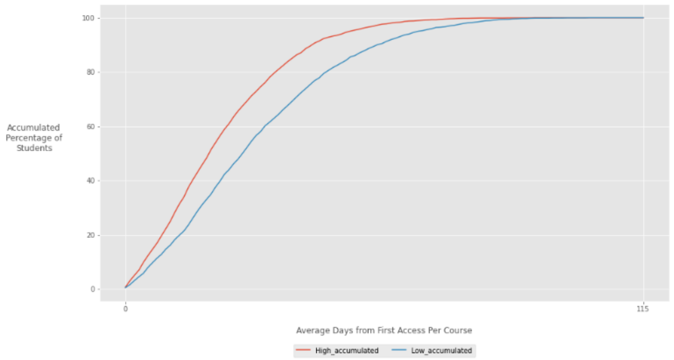


b. Accumulated Percentage

Figure 1. The Percentage of Students per Ranking Visualized According to the Average Days Elapsed From First Access Overall – Ungraded.



a. Raw Percentage

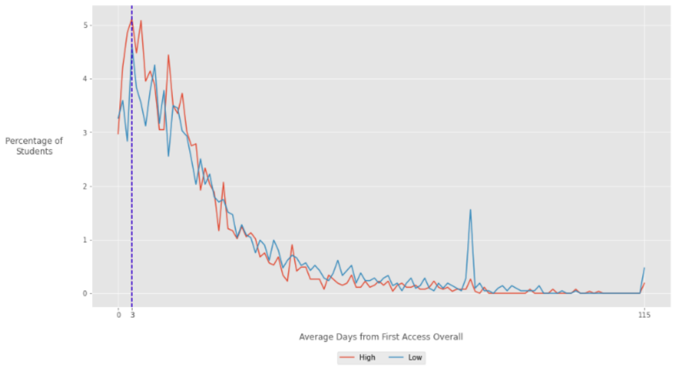


b. Accumulated Percentage

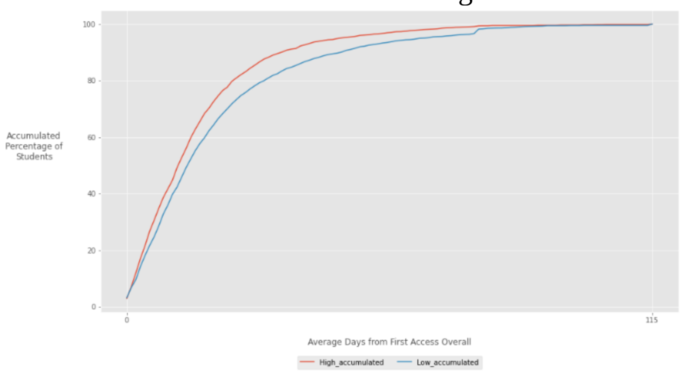
Figure 2. The Percentage of Students per Ranking Visualized According to the Average Days Elapsed From First Access Per Course – Ungraded.

4.2 Accesses-Graded

In both Figures 3a and 4a, it could be clearly seen that the majority of both high-performing and low-performing students begin accessing the graded course discussion forums on the same day – Day 3. In Figure 3a, approximately 5.12% of the high-performing students and 4.63% of the low-performing students begin accessing the graded course discussion forums overall on Day 3. In Figure 4a, on a per course perspective, approximately 5.72% of the high-performing students and 5.25% of the low-performing students begin accessing the course discussion forums 3 days from the initial access. Also, both Figures 3a and 4a do not suggest a significant difference between the high-performing and the low-performing students regardless of the number of days elapsed from the initial access. But when considering the accumulated percentage graphs on Figures 3b and 4b, the high-performing group reaches close to the peak first before the low-performing group.

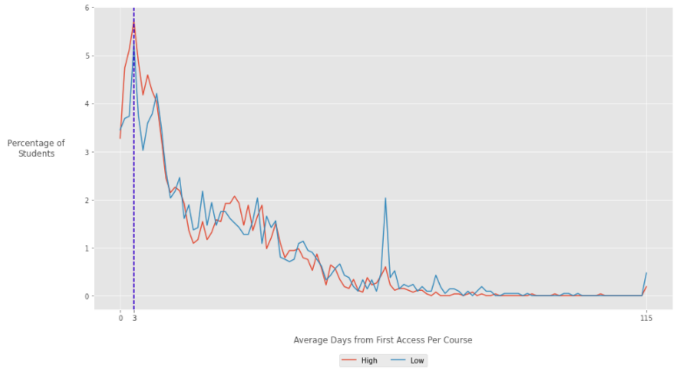


a. Raw Percentage

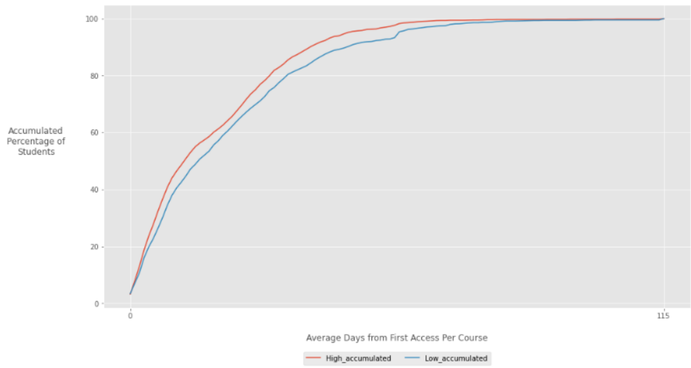


b. Accumulated Percentage

Figure 3. The Percentage of Students per Ranking Visualized According to the Average Days Elapsed From First Access Overall – Graded.



a. Raw Percentage

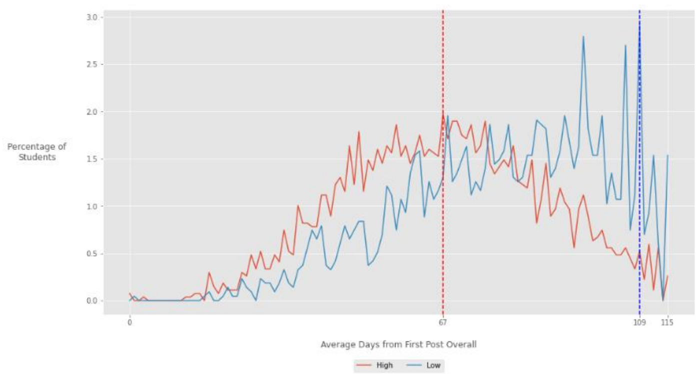


b. Accumulated Percentage

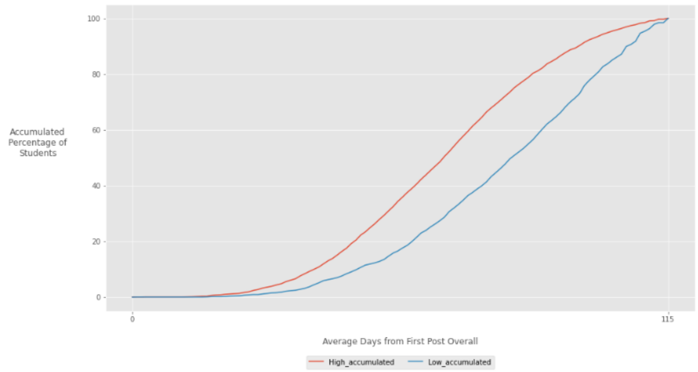
Figure 4. The Percentage of Students per Ranking Visualized According to the Average Days Elapsed From First Access Per Course – Graded.

4.3 Posts-Ungraded

In both Figures 5a and 6a, it could be clearly seen that the majority of the high-performing students begin posting to the ungraded course discussion forums earlier than their low-performing counterparts. In Figure 5a, approximately 1.97% of the high-performing students begin posting to the ungraded course discussion forums 67 days from the initial post overall while around 2.93% of the low-performing students begin posting 109 days from the initial post overall. In Figure 6a, on a per course perspective, approximately 2.72% of the high-performing students begin posting to the course discussion forums 60 days from the initial post, while around 2.09% of the low-performing students begin posting to the course discussion forum 88 days from the initial post. Also, as the days elapsed from the initial post increases, the percentage of low-performing students begin to outnumber the percentage of the high-performing students. When considering the accumulated percentage graphs on Figures 5b and 6b, the high-performing group reaches close to the peak first before the low-performing group.

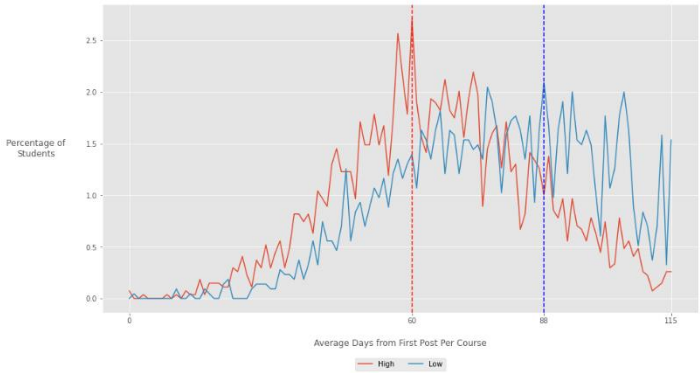


a. Raw Percentage

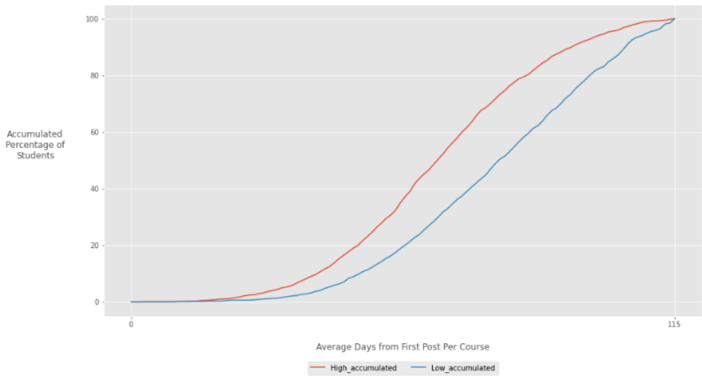


b. Accumulated Percentage

Figure 5. The Percentage of Students per Ranking Visualized According to the Average Days Elapsed From First Post Overall – Ungraded.



a. Raw Percentage

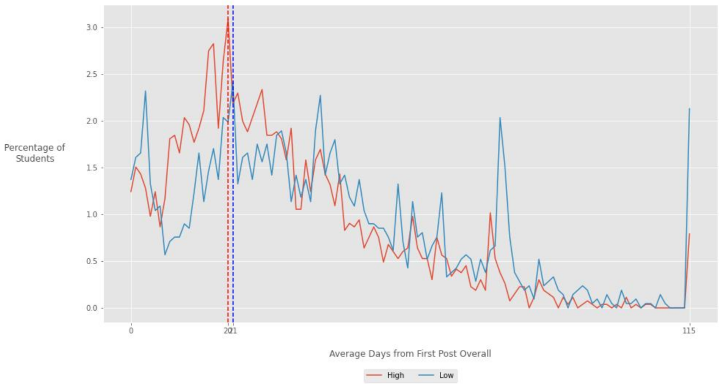


b. Accumulated Percentage

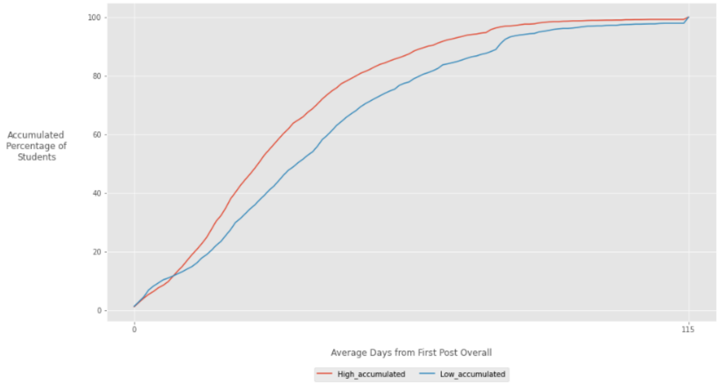
Figure 6. The Percentage of Students per Ranking Visualized According to the Average Days Elapsed From First Post Per Course – Ungraded.

4.4 Posts-Graded

In both Figures 7a and 8a, it could be clearly seen that the majority of the high-performing students begin posting to the graded course discussion forums earlier than their low-performing counterparts. In Figure 7a, approximately 3.09% of the high-performing students begin posting to the graded course discussion forums 20 days from the initial post overall while around 2.41% of the low-performing students begin posting 21 days from the initial post overall. In Figure 8a, on a per course perspective, approximately 2.98% of the high-performing students begin posting to the course discussion forums 31 days from the initial post, while around 2.65% of the low-performing students begin posting to the course discussion forum 57 days from the initial post. Also, both Figures 7a and 8a do not suggest a significant difference between the high-performing and the low-performing students regardless of the number of days elapsed from the initial access. What is more alarming, however, is the relatively high percentage of low-performing students who did not post at all to a graded discussion forum (Day 115). When considering the accumulated percentage graphs on Figures 7b and 8b, the high-performing group once again reaches close to the peak first before the low-performing group.

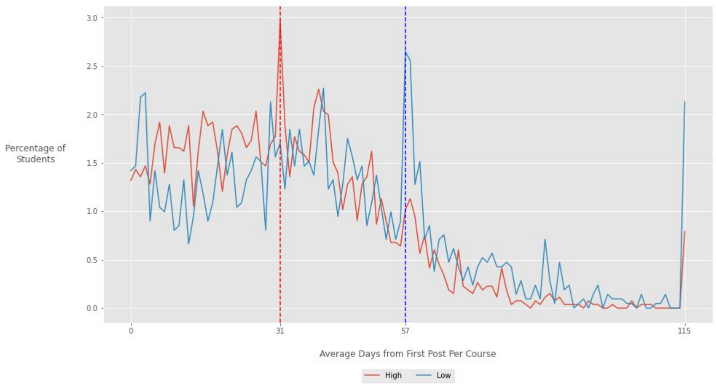


a. Raw Percentage

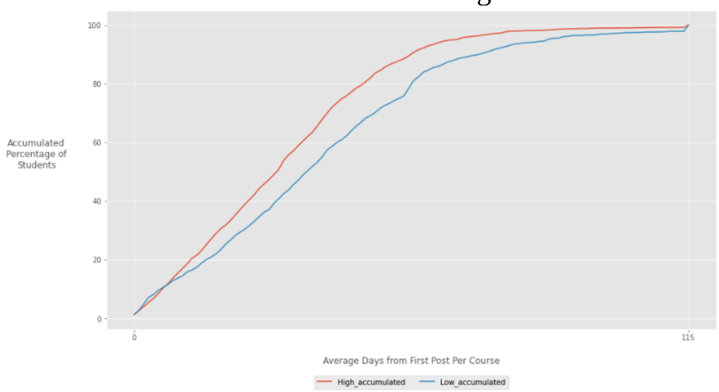


b. Accumulated Percentage

Figure 7. The Percentage of Students per Ranking Visualized According to the Average Days Elapsed From First Access Overall – Graded.



a. Raw Percentage



b. Accumulated Percentage

Figure 8. The Percentage of Students per Ranking Visualized According to the Average Days Elapsed From First Access Per Course – Graded.

4.5 Association Rules Analysis

In Table 1, when looking at an overall level, the high-performing students post/access the online course discussion forums earlier than the low-performing students. Furthermore, those who fail to post in a graded online course discussion forum are more likely to perform poorly. On the other hand, when looking on a per course level (Table 2), the same pattern also emerges in that low-performing students make their initial post/access much later compared to the high-performing students, and that those who did not make a single post at all in a graded course discussion forum are all the more likely to have low performance.

Table 1. *Top 5 Association Rules Analysis Results for the Averaged Days Elapsed from First Access or Post Overall*

Access Ungraded	Access Graded	Posts Ungraded	Posts Graded	Performance	Accuracy
N/A	N/A	Day 25 to 30	Day 7 to 12	High	0.99
N/A	Day 73 to 78	N/A	None	Low	0.99
Day 1 to 6	N/A	Day 13 to 18	N/A	High	0.98
Day 43 to 48	N/A	Day 61 to 66	N/A	High	0.98
N/A	N/A	Day 31 to 36	Day 19 to 24	High	0.97

Table 2. *Top 5 Association Rules Analysis Results for the Averaged Days Elapsed from First Access or Post Per Course*

Access Ungraded	Access Graded	Posts Ungraded	Posts Graded	Performance	Accuracy
N/A	N/A	Day 109 to 114	None	Low	0.99
N/A	N/A	Day 103 to 108	None	Low	0.99
Day 1 to 6	N/A	Day 19 to 24	N/A	High	0.98
Day 79 to 84	N/A	N/A	N/A	Low	0.98
Day 67 to 72	N/A	N/A	Day 55 to 60	Low	0.96

5. Conclusion, Limitations, and Further Studies

Overall, the visualizations showed that, regardless whether the course discussion forum is graded or not, a high percentage of the high-performing students made posts and accesses earlier than the low-performing students. When the percentages are accumulated, almost the entire high-performing group made their initial access/posts before the entire low-performing group does. On the other hand, the association rules showed that performing initial accesses or posts later, or even not post in a graded online course discussion forum at all, is an indicator of possible poor performance. These features may be helpful in identifying students who are likely to procrastinate and may cue intervention.

This study, though, is subject to several limitations. Student performance is defined as the estimated overall average grade the student has received for all courses, and course contents were not taken into consideration. There are other indicators of student performance or behavioral factors such as fear, perfectionism, and motivation. Future studies can take these into consideration.

Detecting procrastination behavior is the first step in mitigating it. Suggested interventions from prior research include but are not limited to making forum participation compulsory (Gafni & Geri, 2010), converting large, one-off course requirements into smaller requirements spread throughout the academic term (Kang & Zhang, 2020), providing scaffolding to help extreme procrastinators learn more adaptive learning strategies (Cerezo, Sánchez-Santillán, Paule-Ruiz, & Núñez, 2016), and greater social support (Liimatta, 2021). Future research could try to implement these strategies and measure their effects on student online participation.

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Analysis of the Connection of United Nations Sustainable Development Goals with the Hong Kong High School Technology Curriculum

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Abstract: United Nations Sustainable Development Goals (SDGs) Target 4.7 stated that by 2030, all learners should acquire the knowledge and skills needed to promote sustainable development. However, only scattered studies outline how SDG knowledge has been taught and assessed in public K12 curricula. This study uses a machine learning approach to identify SDG topics in five technology-related subjects in the Hong Kong Diploma of Secondary Education curriculum. A public training dataset from OSDG and descriptions of subjects were used for the classification. Results of module-/subject-/curriculum-level analysis were used to illustrate the adopted approach's functions.

Keywords: Sustainable Development Goals, classification, curriculum analysis, K12

1. Introduction

In 2015, United Nations established 17 sustainable development goals (SDGs) on sustainable economic growth and social development (United Nations General Assembly, 2015). Target 4.7 stated that by 2030, all learners should acquire the knowledge and skills needed to promote sustainable development. Strategies are needed for the advancement of the SDG education. Hurd and Ormsby (2020) studied how teachers in four US K12 schools taught SDGs in the lesson level. Meanwhile, Zguir, Dubis and Koc (2021) illustrated how governments in countries designed K12 sustainability education at the policy level. However, only scattered studies outline how SDGs have been taught and assessed in the regional or national public K12 curricula. In other words, no mechanisms or protocols have been proposed to analyze how much SDG knowledge have K12 students learned in the curriculum. Measuring the proportion of students who have studied SDGs or sustainability topics during their K12 learning is not easy. For example, Gallwey (2016) discussed challenges in holistically measuring how SDGs have been taught. Furthermore, the curriculum analysis could be challenging to match SDGs with public curricula in practice. Subject teachers also may have difficulties holistically understanding all 17 SDGs. The main purpose of this study is to identify the connection of the SDG education with the general public high school (K10 – K12) technology curriculum in Hong Kong. The research question is: How can topics in high school technology subjects be classified through machine learning according to SDGs? Through the finding of the investigation, government policymakers and school administrators can be more informed about developing high school technology curricula considering SDGs. With better integration of SDGs into the technology curriculum, students are more prepared to adopt technologies to benefit community and the environment by 2030.

2. Research Method

This study analyzes the contents of SDGs in five technology-related subjects provided by high schools (K10 – K12) in Hong Kong. These scope of these subjects are defined in the curriculum of the Hong

Kong Diploma of Secondary Education (HKDSE) by the Hong Kong Examinations and Assessment Authority (HKEAA). The following five technology-related subjects have been analyzed in this study: i) design and applied technology (DAT), ii) health management and social care (HMSC), iii) information and communication technology (ICT), iv) technology and living (TL), and v) Business, Accounting and Financial Studies (BAFS). Every subject has multiple major modules, and the estimated lesson time for each subject is around 250 hours. Subject content is manually extracted from PDF documents located on the HKEAA website. Module introduction, "topics to be learned", and "descriptions of the module" are used to describe the subject. Every subject has its own instruction style, therefore, they do not share an aligned structure of the syllabus.

Meanwhile, our training dataset comes from the OSDG Community dataset (OSDG, 2021). The dataset is mainly based on reports and policy documents from United Nations. These documents are publicly available and often already have SDG labels associated with them. The OSDG community decomposed these documents into records. In 2021, there were around 32000 records of text comprised of 3 to 6 sentences. More than 1000 community volunteers then validated the records on the relevance to originally tagged SDGs. The dataset only includes SDGs between 1- 15 because SDGs 16 and 17 are overarching goals that might pop up in almost all kinds of texts.

The classification procedure that has been used to analyze a university's general education curriculum (Lei et al. 2022) has been used for analyzing DSE technology curriculum. In the machine learning process, frequency-inverse document frequency (TF-IDF) is used in the feature extraction. A multinomial logistic regression algorithm is used for the classification. Relative SDG relevance scores across SDGs 1 to 15 can be obtained for every module of subjects. If the relative relevance score of an SDG is larger than 0.09 (an arbitrary threshold), that SDG will be claimed to be taught in that module.

3. Results

3.1 Module Level Analysis

Figure 1 shows the classified SDGs of two modules in two subjects. Based on Fig. 1 (Left), the module "Entrepreneurship and Enterprise" in the DAT mainly focuses on economic-related SDGs, including SDGs 8 (Decent Work and Economic Growth), 9 (Industry, Innovation and Infrastructure) and 12 (Responsible Consumption and Production). As shown in Fig. 1 (Right), the module "Nutrition, Diet and Health Concerns" in DT mainly focuses on SDGs 2 (Zero hunger) and 3 (Good health and well-being). Generally, in most modules, only one major SDG can be classified. We believe with studying these modules, students can have a better understanding of topics of the classified SDGs.

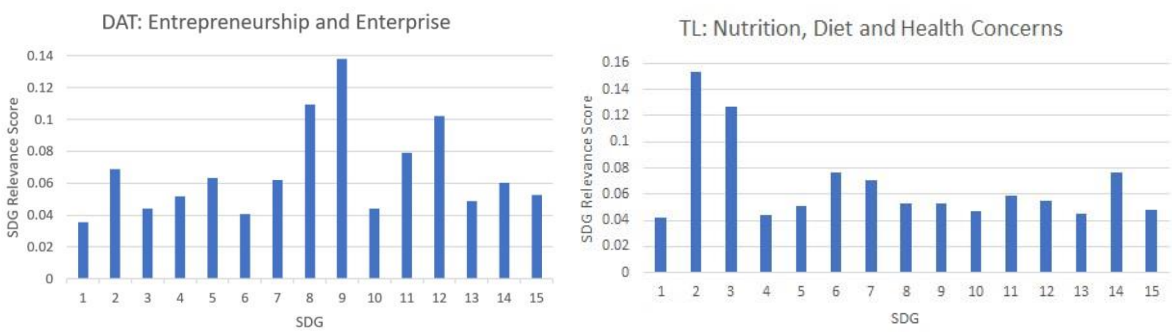

Figure 1. Relative SDG relevance scores in two modules in DAT (Left) and TL (Right).

3.2 Subject / Curriculum Level Analysis

Table 1 shows how SDGs have been taught in the DSE technology curriculum. Results indicated that each subject has its own focus. For example, BAFS and ICT strongly focuses on SDGs 8 and 9, respectively. Every module in HMSC is related to SDG 3. Their focus can also be observed directly via their module title. In TL, seven modules strongly focuses on SDG 2 since these modules mainly focus on nutrition and cooking. Meanwhile, discussions of another seven modules in TL are on textiles and clothing. Therefore, discussions of these modules covers a variety of SDGs. Meanwhile, DAT covers a spectrum of SDGs, indicating the subject is about applying technologies to resolve various sustainability issues in the community.

Compared to curricula in universities (Lei et al. 2022), the K12 DSE curriculum is found to be less focused on SDG 9. This may be because the high school curriculum focuses more on the foundations of subjects; universities concentrate more on teaching cutting-edge and frontier topics. Topics in SDGs 10 (Reduced inequalities) and 13 (Climate action) are also not yet well discussed in the DSE technology curriculum. We believe these topics are mainly discussed in the "Citizenship and Social Development" DSE curriculum and partially in the humanities and geography DSE curricula.

Table 1. *Number of SDGs Classified in Subject Modules (#: Number of Modules in the Subject): (a) Total number of SDGs Classified, and (b) Proportion (Rounded) of SDGs Classified*

(a)

SDG #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	#
DAT		2		4			1	1	19		2	8		3	1	27
HMSC	1	1	22	1	4	1		1	1						1	22
ICT			3						7							7
TL		7	4		2		1	1	2			4			1	14
BAFS				1	1		2	5	3		1	3		2		11

SDG #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
DAT		5%		10%			2%	2%	46%		5%	20%		7%	2%
HMSC	3%	3%	67%	3%	12%	3%		3%	3%						3%
ICT			30%						70%						
TL		32%	18%		9%		5%	5%	9%			18%			5%
BAFS				6%	6%		11%	28%	17%		6%	17%		11%	

4. Conclusion

Machine learning has been used to identify how SDGs have been taught in five technology-related K12 subjects in Hong Kong. The conducted module-/subject-/curriculum-level analysis indicates the strength and weaknesses of these subjects in covering SDGs in their curriculum. In the future, we aim to conduct a human verification of the results of the classifications based on machine learning. Furthermore, we also hope to classify all STEM-related subjects (e.g., geography) and other subjects in HKDSE, such that we can have a holistic understanding on how K12 students in Hong Kong have learned SDGs through the public curriculum. Furthermore, we want to know how the curriculum can be effectively aligned with SDGs. Therefore, we should collect feedback from principals, teachers, students and other stakeholders. In particular, we should identify the missing pieces in curricula and potential resources that should be provided for promoting SDG education in K12. For example, we can explore whether MOOCs can be used as a supplement for enriching SDG education in K12.

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A Quality Data Set for Data Challenge: Featuring 160 Students' Learning Behaviors and Learning Strategies in a Programming Course

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Abstract:

Emerging science requires data collection to support the research and development of advanced methodologies. In the educational field, conceptual frameworks such as Learning Analytics (LA) or Intelligent Tutoring System (ITS) also require data. Prior studies demonstrated the efficiency of academic data, for example, risk student prediction and learning strategies unveiling. However, a publicly available data set was lacking for benchmarking these experiments. To contribute to educational science and technology research and development, we conducted a programming course series two years ago and collected 160 students' learning data. The data set includes two well-designed learning systems and measurements of two welldefined learning strategies: Self-regulated Learning (SRL) and Strategy Inventory for Language Learning (SILL). Then we summarized this data set as a Learning Behavior and Learning Strategies data set (LBLS-160) in this study; here, 160 indicates a total of 160 students. Compared to the prior studies, the LBLS data set is focused on students' book reading behaviors, code programming behaviors, and measurement results on students' learning strategies. Additionally, to demonstrate the usability and availability of the LBLS data set, we conducted a simple risk student prediction task, which is in line with the challenge of cross-course testing accuracy. Furthermore, to facilitate the development of educational science, this study summarized three data challenges for the LBLS data set.

Keywords: Educational data, learning analytics, AIED

1. Introduction

Artificial Intelligence (AI) can be implemented as a software agent to handle routine human tasks (Russell, 2010). AI has rapidly grown due to the rise of big data and machine learning technologies. Several AI applications constructed by data have already been implemented in the real world. For example, Devlin, Chang, Lee, and Toutanova (2018) designed a bi-directional model to let machines construct the capability to understand human language. The model supported four tasks: Next Sentence Prediction (NSP), Masked Language Model (MLM), Single Sentence Tagging (SST), and QuestionAnswering (QA). The performance evaluation results demonstrated that the work is the state-of-the-art machine reading comprehension model after training the parameters using 2,500M+800M words from Wikipedia articles and BooksCorpus. Many researchers involved in foundation work on data to support AI research and development. For example, Deng et al. (2009) hosted a project named ImageNet, which collected 14M images till May 11, 2021. Follow-up researchers benchmarked their AI model based on ImageNet, such as Krizhevsky, Sutskever, and Hinton (2012) evaluated the Convolutional Neural Network (CNN) performance on the data set. The above works indicated training a machine as an agent for supporting human's routine tasks, data playing a significant role in model research and development, and an opened data set is also essential for model performance benchmarking.

AI in education can be referred to the Intelligent Tutoring System (ITS), which goal is providing near real time personalized feedbacks to learner (Hwang, Xie, Wah, & Gašević, 2020). One kind of implementation is video recommendation system, which push a video with missing context to a student based on their learning pathway or concept proficiency, priori studies also demonstrated its efficiency on students' learning performance (L. Leite et al., 2022). Meanwhile, to implement ITS, machine learning techniques, algorithms, datasets are also required components (Khanal, Prasad, Alsadoon, & Maag, 2020). When it comes to data applications in education, learning analytics is another implementation. Learning analytics is defined as a kind of data-driven application in educational field (Cristobal Romero & Ventura, 2020). The goal is improving students' learning performance based on data analysis results (Clow, 2013). One of the popular implementations is predicting at-risk students. For example, Cristóbal Romero, López, Luna, and Ventura (2013) demonstrated the potential to identify risk population by using students' level of discussion participation in early semester. Choi, Lam, Li, and Wong (2018) demonstrated a 7% improvement on learning performance after intervening risk population that identified by prediction model that trained by students' clicker data. On the other hand, to offer correct intervention to risk population, researchers applied learning strategy approaches. For example, Jovanović, Gašević, Dawson, Pardo, and Mirriahi (2017) unveiled students' self-regular learning strategy by using sequence clustering on students' book reading behaviors.

The currently opened data sets has several characteristics. The earliest opened educational data set can be traced back to 2008 (Cortez & Silva, 2008), containing 30 variables, such as gender and school, from the Mathematics and Portuguese language course. The latest opened educational data set can be found in 2022 (Flanagan, Majumdar, & Ogata, 2022), which contains 120 students with 17 variables. Perhaps due to the advancement of technology, the data collected has become more diverse. From the beginning, most data set only collected demographics such as gender and age (Amrieh, Hamtini, & Aljarah, 2016; Cortez & Silva, 2008; MITx). In recent years, logs from the learning system have appeared, such as video viewing behavior on MOOCs (Kellogg & Edelmann, 2015), discussions on LMS (Amrieh et al., 2016), and book reading behavior on e-Book (Flanagan et al., 2022). Algebra (Stamper, NiculescuMizil, Ritter, Gordon, & Koedinger, 2010) and Mathematics (Cortez & Silva, 2008) were the most popular subjects for the data collection task. But on the other side, some data sets do not specify subjects or contain almost all subjects (MITx).

To sum up, we can understand the importance of open data sets to contemporary education technology development, but the currently available data sets focused on learning behaviors but overlooked learning strategies. Therefore, this study aims to define and publish a data set that measures learning behaviors and strategies and then attempts to facilitate learning analytics research and development through several scientific challenges.

1. We conduct a programming course for continuing to open a new educational data set for the development of AIED research.
2. In addition to reading behavior, this data set will disclose students' learning strategies and coding behavior, which will be more extensive than the previous data sets.
3. To confirm the data quality, we define an evaluation process and demonstrate the usability of the proposed data set. Meanwhile, we explained a few potential data challenges for future works.

2. Literature Reviews

2.1 How to evaluate the data quality?

Data would not achieve the research goal if we released it after collection directly. A suitable evaluation process can make subsequent research and development more effective. Therefore, our idea is to challenge a topic before opening, review its effectiveness and use it as a baseline for future challenges.

Among the functionality of education data, Cristobal Romero and Ventura (2020) defines (1) Educational Data Mining (EDM), which explores methods to recognize learning patterns or critical factors in education data, and (2) Learning Analytics, which uses educational data to optimize the learning environment or to improve learning performance. This study will focus on the early stage of

LA because EDM requires more data sets to benchmark the methods. In practice, the LA presented by Cristóbal Romero et al. (2013) used students' participation in the discussion forum to predict students' learning performance, and they tested the Accuracy of various classification algorithms.

In another review, Conijn, Snijders, Kleingeld, and Matzat (2016) conducted a large-scale analysis on the risk student prediction task. They collected 17 courses from LMS and adopted the same methodologies mentioned above to understand the characteristics of the learning analytics research. The results demonstrated rich classification Accuracy of the risk prediction model on verification of the same course but poor on cross-course validation. In summary, to evaluate the data quality, this study will implement a learning analytics task of predicting student risk while cross-validating individual courses and courses by using a convention classification algorithm and indicator. The result is expected to be consistent with Conijn et al. (2016), and some problems encountered could be defined as future challenges.

2.2 What else data could be collected in classroom?

Learning strategy indicates to a student how to construct knowledge in the classroom; therefore, students' strategy measurement becomes another critical factor to be recorded. The self-regulated learning proposed by Zimmerman and Schunk (2001) aims to explore the process of students' acquisition of knowledge in the three stages of forethought, monitoring, and self-reflection. During the programming process, students learn to solve problems and develop programming skills during the phases of understanding the problem, planning and implementing solutions, and evaluating potential solutions. It can be seen that the stages of the programming process are similar to the self-adjustment behaviors of planning, goal setting, organization, self-monitoring, and self-evaluation in self-regulated learning. In view of this, Shin and Song (2022) have proposed that students' self-regulated learning ability need to guide to promote students' programming skills in the problem-solving process. Therefore, Shin and Song (2022) further defined the learning tasks corresponding to the three stages of selfregulated learning in the programming process. In addition, previous research literatures found that students' self-regulated learning ability is closely related to programming learning performance (Cigdem, 2015; Echeverry, Rosales-Castro, Restrepo-Calle, & González, 2018).

On the other hand, researchers tried to adopt learning strategies for natural languages in programming courses. They demonstrated high potential because of (1) the similar aspects of syntax, lexicon, and semantics (Ernst, 2017) and (2) the efficiency of students' learning performance. In the efficiency aspect, for instance, Sun and Frederick (2015) proposed a framework named: SLA-aBLe (Second language acquisition to facilitate a blended learning); they demonstrated the improvement of student's learning motivation and performance by constructing connections between vocabulary and programming syntax. Many researchers adopted Strategy Inventory for Language Learning (SILL)(Oxford & Burry-Stock, 1995) to measure students' natural language learning strategies. Essentially, it is because it provides an explicit intervention action if students' measurement results are below the average; for example, teachers should add more images in learning material to increase their memory retention rate. Therefore, this study will use SILL to measure students' capability of language learning strategy.

3. Methods

3.1 Participants

As shown in Figure 1, LBLS-160 data sets were collected from three programming language classes which Class A, B, and C have 63, 56, and 41 students, totaling 160 students. The teacher, learning materials, content, syllabus, homework, grading policies, and learning durations were all the same in this course. The only difference is that Class A and B are in the same semester, and Class C is in another semester. The 160 participants in the course were all from university, non-computer science-related departments, and they were all learning programming languages for the first time. LBLS-160 collects two kinds of data: learning behaviors and learning strategies, and it will be explained in detail at next section.

		Learning Behaviors		Learning Strategies		
	Participants	BookRoll	VisCode	SRL Motivation	SRL Strategy	SILL
Class A	63	✓	✓	✓	✓	✓
Class B	56	✓	✓	✓	✓	✓
Class C	41	✓	✓	✓	✓	

Total: 160 Non-CS Students

Figure 1. The number of students and features in LBLS-160.

3.2 Data Collection

LBLS-160 includes two parts. The first is individuals' learning behaviors collected from two online learning environments. The second is individuals' learning strategies which are measured using two different questionnaires.

Two learning environments include BookRoll(Ogata et al., 2015) and VisCode(Lu, Huang, Huang, Huang, & Yang, 2016) as shown in Figure 2; both software was designed for teachings and have a complete learning logs recording function for learning analytics research. BookRoll is an e-book software for teachers to upload and manage teaching materials; for learners to read through the Internet. BookRoll provides functions such as Maker and Memo and saves learners' reading records as a Log file. VisCode is an integrated development environment for teachers to upload sample codes; learners to develop scripting programming languages, execute and test. VisCode stores the programs and development records created and interacted with learners.

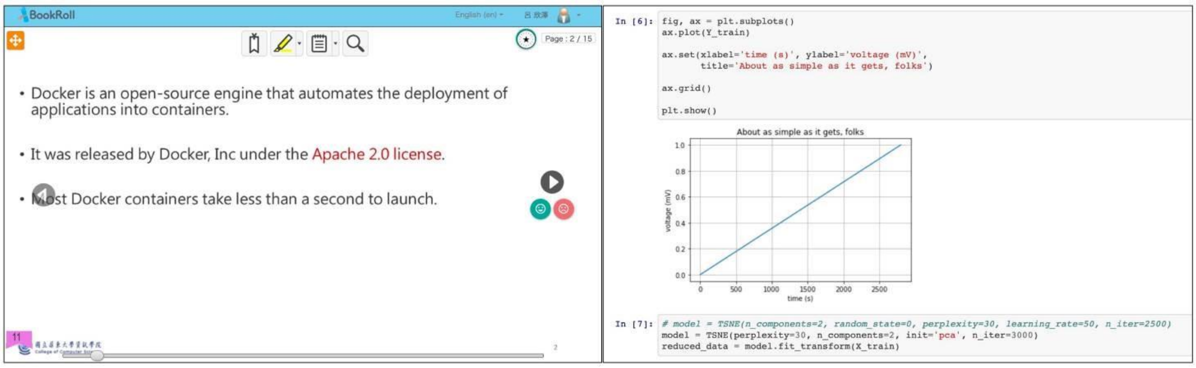

Figure 2. Learning environment, BookRoll (L) and VisCode (R).

Learning strategies include Self-regulated Learning (SRL)(Zimmerman & Schunk, 2001) and Strategy Inventory of Language Learning (SILL)(Oxford & Burry-Stock, 1995). According to the survey from prior studies in the literature review section, we can consider learning strategies an essential factor in supporting learners in improving their learning performance. In SRL, the Learning Motivation Strategies Questionnaire (MSLQ) with a 5-point Likert scale proposed by Pintrich (1991) has gradually been used to measure learners' self-regulation ability, it mainly includes two scales of learning motivation and learning strategy. The learning motivation scale has 31 questions, including six phases of intrinsic goal orientation, extrinsic goal orientation, task value, control belief, learning and performance self-efficacy, and test anxiety. The learning strategy has 50 questions, including nine phases of rehearsal, elaboration, organization, critical thinking, metacognitive self-regulation, time and study environment, effort regulation, peer learning, help seeking. In SILL, we measured six phases by 48 questions with 5 points Likert scale: the cognitive phase, compensation phase, social phase, affective phase, meta-cognitive phase, and memory phase.

3.3 Learning Activities

The course aims to teach the basic Python programming knowledge. There are eight basic Python programming concepts: (1) *input and output*, (2) *variables*, (3) *lists*, (4) *conditions*, (5) *for-loop*, (6) *while-loop*, (7) *dictionary*, and (8) *functions*. This course contained three stages: before-class, in-class, and after-class. In the stage of before-class, each student required to preview learning materials on BookRoll. There are three actions has to be done in stage of in-class: teacher will give an instruction based on learning materials, students have to take a program challenge assigned by teacher, and teacher will explain the solution of the challenge before the end of class. In the stage of after-class, each student has to practice three to five Python assignments on VisCode.

3.4 Data Preprocessing

We took a few preprocesses before releasing LBLS-160. The first is de-identification by removing direct recognition fields such as students' first and last names and encoding students' identification as a unique code: "userid" in each data set. Students will obtain the same code in different subsets but unique code in the same subsets to fulfill the subset merge subsets requirement. The second is to fill the ignored responses to be 0 in the questionnaire measurement process. The last one is to encode headers to make data more readable. For example, the first question in the SRL motivation questionnaire will be encoded into "srl_m_1". On the other hand, although it is important to use features that are critical to learning outcomes, but in this study, because the data has not been validated, we used data that can be collected in two learning environments for validation, as listed in Table 1 and Table 2:

Table 1. Features of book reading behaviors (BookRoll).

Features	Description
userid	Anonymized student userid, eg: b1dfc5c6ec04d46d1823c5fa972ad320
ADD BOOKMARK	Added a bookmark to current page.
ADD MARKER	Added a marker to current page.
ADD MEMO	Added a memo to current page.
ADD_HW_MEMO	Added a handwrite memo to current page.
BOOKMARK_JUMP	Jump to a specific page with a bookmark.
CHANGE MEMO	Modify the content of an existing memo on current page.
CLEAR_HW_MEMO	Clear the content of an existing handwrite memo on current page.
CLOSE	Closed the book.
CLOSE_RECOMMENDATION	Deleted an exist bookmark in the e-book.
DELETE BOOKMARK	Deleted a bookmark on current page.
DELETE MARKER	Deleted a marker on current page.
DELETE_MEMO	Deleted a memo on current page.
GETIT	Press the smiley face icon to indicate the understanding on current page.
MEMO_JUMP	Select a note to jump to the specific page.
NEXT	Went to the next page.
NOTGETIT	Press the crying face icon to indicate the misunderstanding on current page.
OPEN	Opened the book.
PAGE_JUMP	Jumped to a particular page.
PREV	Went to the previous page.
SEARCH	Searched for something within the e-book.
SEARCH_JUMP	Jumped to a page from the search results.
UNDO_HW_MEMO	Undo the last action of handwriting.

Table 2. Features of programming coding behaviors (VisCode).

Features	Description
id	Anonymized student userid, eg: b1dfc5c6ec04d46d1823c5fa972ad320
code_length	Nunber of lines of code (LOC) coded in this semester.
code_copy	Number of times a student copy codes.
code_execution	Number of times a student execute codes.
code_paste	Number of times a student paste codes.
code_speed	Average input digits per minutes.
notebook_open	Number of times a student open coding environment.
Features	**Description**
tree_open	Number of times a student open a folder looking for a code.
AttributeError	Raised when attribute reference or assignment fails.
ConversionError	Failed to convert value(s) to axis units.
FileExistsError	Raised when trying to create a file or directory which already exists.
FileNotFoundError	Raised when a file or directory is requested but doesn't exist.
IndentationError	Base class for syntax errors related to incorrect indentation.
IndexError	Raised when a sequence subscript is out of range.
JSONDecodeError	Raised if the given JSON document is not valid.
KeyError	Raised when a mapping (dictionary) key is not found in the set of existing keys.
KeyboardInterrupt	Raised when the user hits the interrupt key (normally Control-C or Delete).
LookupError	The base class for the exceptions that are raised when a key or index used on a mapping or sequence is invalid: IndexError, KeyError.
ModuleNotFoundError	A subclass of ImportError which is raised by import when a module could not be located.
NameError	Raised when a local or global name is not found.
OperationalError	Exception raised for errors that are related to the database's operation, and not necessarily under the control of the programmer.
SyntaxError	Raised when the parser encounters a syntax error.
TabError	Raised when indentation contains an inconsistent use of tabs and spaces.
TypeError	Raised when an operation or function is applied to an object of inappropriate type.
UnboundLocalError	Raised when a reference is made to a local variable in a function or method, but no value has been bound to that variable.
UnicodeDecodeError	Raised when a Unicode-related error occurs during decoding.
ValueError	Raised when an operation or function receives an argument that has the right type but an inappropriate value, and the situation is not described by a more precise exception such as IndexError.
ZeroDivisionError	Raised when the second argument of a division or modulo operation is zero.

3.5 Evaluation

To evaluate LBLS-160 quality and establish the baseline performance for the follow-up challenges, we conducted a risk prediction experiment to assess if the data set achieved self-predictable goals. Due to the data set being merged from learning logs and questionnaire measurement results, we referred to prior studies to define the evaluation process, as shown in the Figure 3.

1. **Normalization:** Learning behaviors and learning strategies were specified on different scales. Learning logs were the behavior count, and questionnaire measurement results were the level of learning strategy capabilities determined by Likert Scales. Therefore, a normalizer is necessary to consistent both scales.
2. **Principal Component Analysis (PCA):** The proposed LBLS-160 data set has 56 features merged from two learning logs and one questionnaire measurement; not every feature was critical for the evaluation task. Therefore, we adopted PCA to identify critical features.

3. **Support vector machine (SVM):** In this experiment, we divided students into risk and non-risk, then used the proposed LBLS-160 data set to teach a computer how to classify each other. Therefore, the classification algorithm was picked-up for this sub-process.

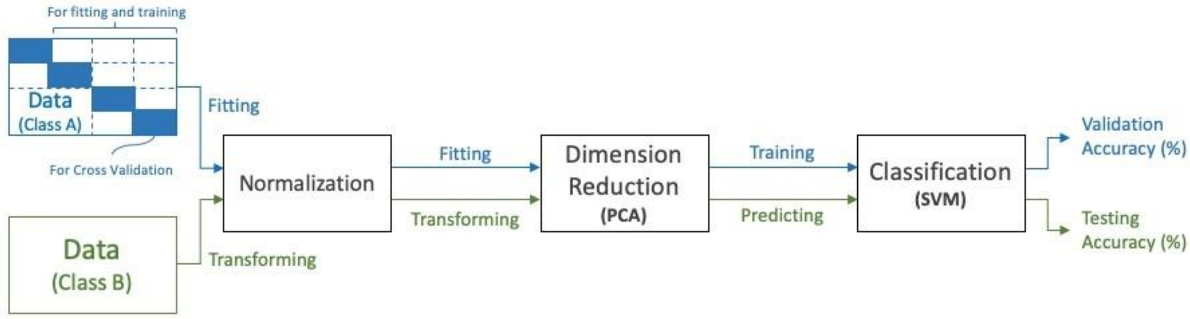

Figure 3. Cross-class risk prediction model evaluation process.

A cross-class evaluation has been conducted in this experiment. We will target one subset from a specific class to fit the normalizer, PCA, and to train the model. Here "class" specified a course in a particular duration of time instead of categories in the machine learning dictionary. Validation accuracy was obtained when we input a split training set into the model, and the accuracy should present outstanding performance to prove the self-predictable concerns. On the other hand, testing accuracy was obtained when we input subsets from different classes.

4. Results and Discussions

This experiment proves that Class A and Class B's feature has similar distributions. Still, Class C has fewer generalization characteristics than Class A and B. This observation is in line with the survey results on different data sets by Conijn et al. (2016) on different data sets. In the evaluation process, first, since the data set includes a total of 131 features, as mentioned in the literature review section, we need to perform PCA to reduce the dimensions. Using Class A as an example, the PCA results are shown in Figure 4. When the Cumulative Explanation Variance (CEV) reaches 80%, 10 components are found, and the 10 vectors along with components are used to reduce the dimension of Class B and C.

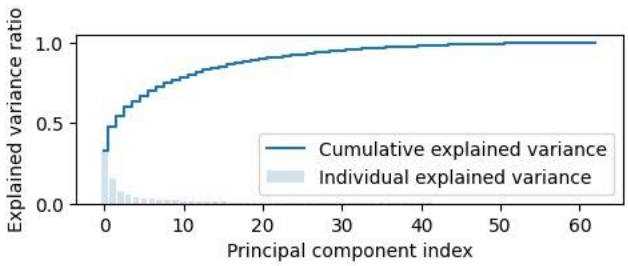

Figure 4. PCA results of Class A, CEV=80%, then Components=10

After normalization, the overall accuracy evaluation results of the training model are shown in the Figure 3. The horizontal axis represents the final grade of the course. First of all, taking the final grade of 80 points as an example, it means we labeled students with grades lower than 80 as True(T) and others as False(F). Then we calculated a T/F balance ratio by using the number of T divided by the number of F. The ideal T/F balance ratio is one, which represents the number of T and F were equaled (Lu, Huang, & Yang, 2021). At this time, the blue bar on points of 80 in this figure means the T/F balance ratio of Class A is around 0.5, which might encounter unbalanced issues, making the Accuracy of the model non-referenceable. In this case, the ideal final grade for training the model is between 84 and 88, marked in red in this figure. In addition, the figure's vertical axis represents Model A's Accuracy. It shows the validation accuracy of Model A for Class A is 0.81, and the cross-course test accuracy for Class B and Class C is 0.77 and 0.67, respectively.

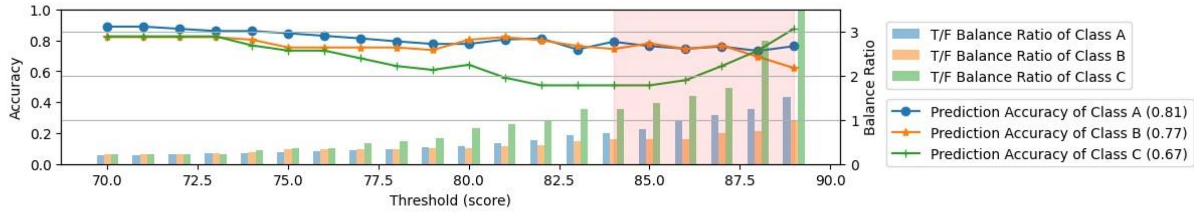

Figure 5. Prediction accuracy of Model A and True(T)/False(F) balance ratios for each class.

Table 3 lists the model's validation and testing accuracy, which was trained by components with CEV larger than 80% and individually classified the training set by final grades of 84 to 87. In the table, Model A indicates that the model is trained with the data of Class A and validates the classification accuracy of Class A, testing the classification of Class B and C, respectively. Then got average Accuracy on Class A: 0.78, Class B: 0.71, and Class C: 0.57. Model B and Model C, and so on. The results of all three experiments show that the validation accuracy is higher than the test accuracy.

The above evaluation results can be discussed that LBLS-160 has the potential to be the data challenge target. There are two significant reasons. First, Class A and Class B are in the same semester, under the condition that the syllabus, homework, and progress are almost consistent; therefore, the Accuracy of Model A and Model B are similar. However, the current evaluation used the most common SVM for the model training; although the validation accuracies are all around 0.8, it still has the possibility to be improved by applying other algorithms. Second, although the syllabus and homework of Class C are consistent with Class A and Class B, but there may be some biases in the implementation of the curriculum for teachers. Therefore, the accuracy of Class C is low compared with the other two classes. This result shows that the model does not have generality. This illustrates the issue where risk prediction models are not available in practical scenarios so that it will become one of the challenges in the future.

Table 3. Cross-class risk prediction accuracy (CEV>80%, final grade: 84~89).

	Model A	**Model B**	**Model C**
Class A	**0.78**	0.61	0.56
Class B	0.71	**0.80**	0.67
Class C	0.57	0.60	**0.71**

5. Challenges

Finally, to achieve the goal of facilitating learning analytics research and development, we have sorted out three learning analytics applications raised in recent years and considered to be potentially achieved through LBLS-160 as follows:

1. **Educational data visualization:** In recent years, educational data visualization has become increasingly popular to support learners' monitoring and tracking of their learning status. Researchers summarized a few meaningful research questions on this topic, for example: "Who are the learners?", "What do they do while learning?"(Schwendimann et al., 2016).
2. **Learning strategies unveiling:** This is also a young topic since 2017(Jovanović et al., 2017). Researchers demonstrated learners' book reading behaviors were a piece of evidence of their SRL strategy (Akçapinar, Chen, Majumdar, Flanagan, & Ogata, 2020). Measuring learners' learning strategies using logs instead of questionnaires could be in more real-time and reliable. Therefore, unveiling the correlation between students' learning behaviors and learning strategies will be a reasonable research question in the proposed data set.
3. **Cross-class risk prediction:** Prior studies proved learning logs were valuable materials to identify risk students in the classroom (Conijn et al., 2016; Lu et al., 2016). However, the prediction model in prior studies didn't confirm the generalizable in the cross-class scenario. Model performance benchmark on one opened data set has also not been considered.

Conclusions

This study aims to release LBLS-160, which is an educational data set to facilitate the development of AI in education. We collect data sets from three programming courses containing students' reading behavior, coding behavior, self-regulated learning ability, and language learning strategy. To evaluate the quality of LBLS-160, we conducted an experiment that predicted students' learning performance and whether the indicator: Accuracy, was consistent with prior studies or not. The results indicate the model has acceptable Accuracy if we train and evaluate it in the same classes and unacceptable Accuracy in the cross-class scenario. This issue is consistent with prior studies and establishes a benchmark baseline for future challenges. Based on the characteristics of LBLS-160, several possible contributions could be conducted in the future; the first one is using logs to unveil students' learning strategies instead of using a questionnaire. And a more generalized risk prediction model for diverse curriculum design.

Acknowledgments

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Cultivating and Supporting Learning Analytics Literacy using 3M Analytical Framework

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Abstract: The widespread adoption of personal computers and mobile devices has enabled learning analytics to become more pervasive among teachers, school administrators, students and parents. While the past decade has marked notable advancements in learning analytics, less attention has been paid to the unique characteristics of learning analytics that necessitate the notion of learning analytics literacy. Although researchers have documented the common use and misuse of learning analytics in education, there is still limited research that highlights the importance of cultivating literacy around the use of learning analytics for better understanding of teaching and learning practices. This paper describes how a Micro-Meso-Macro (3M) analytical approach can be used to support and enhance learning analytics literacy among education stakeholders, while raising the prospects of how a systematic implementation of raising learning analytics literacy can be done through two interacting themes: raising awareness and raising criticality.

Keywords: Learning analytics literacy, 3M framework, learning analytics, data literacy.

1. Introduction

Educational data have been readily collected from educational sites and institutions over the past few decades in hopes of providing a better understanding of teaching and learning. However, this avalanche of educational data has also contributed to emergent problems of how data can be better handled and analyzed to provide deeper insights for interventions (e.g., Jambunathan & Venkatesan, 2016; Lee & Tan, 2017). Data analysis has since revolved around the predominant use of learning analytics (LA), among other techniques such as big data methods and methodologies based on Artificial Intelligence (AI). Although LA has greatly influenced and impacted the use of technological tools for teaching and learning across the education spectrum, there remains limited research on how stakeholders within education systems can better interact with and approach the use of LA. In general, this calls for increased cultivation and support of LA literacy to address prominent challenges in adopting LA, such as more considerations that are required to establish communication channels among stakeholders and adopt pedagogy-based approaches to LA (Tsai & Gasevic, 2017). Further, it is imperative to review and further investigate the literacy levels of LA in individuals, factors influencing the use of LA at the institutional level, and educational policies and practices at the macro level across institutes and even possibly at a national level. The research question to be addressed is, “How can we support LA literacy for educational purposes at different levels of an educational ecosystem?”

2. Literature review

2.1 LA literacy

LA holds great potential in supporting personalized feedback at scale but impacts are inconsistent, reflecting the complexity of maximizing gains from using LA. A review of literature on teachers' and students' use of LA revealed that while they perceive LA to be beneficial (Pardo et al., 2019), they require more support to use it effectively (Lim et al., 2020). For instance, studies have found inconclusive effects on students' use of LA (Bodily & Verbert, 2017), as students may struggle to interpret the LA report independently. As such, students' sensemaking of LA relies on the teachers' ability to interpret and communicate the results presented in the LA. Further, teachers are often assumed to be sufficiently well-equipped with the ability to use LA for their lessons (Yilmaz & Yilmaz, 2020). However, teachers struggle to use LA meaningfully in their teaching practice (van Leeuwen, 2019). In Ez-Zaouia, Tabard and Lavoué's (2020) study, teachers misused the LA dashboard that displays students' emotion data as a proxy to evaluate their teaching, broadly associating negative emotions with poor teaching. There appears an integral need for education stakeholders to go beyond the literal acceptance of LA's availability and existence and to transit towards a deeper appreciation and understanding of LA for meaningful use.

While LA can be used as part of mechanisms for closing the feedback loop during teaching and learning, the generalization of LA as a form of feedback often overlooks the unique characteristics and competencies required to utilize LA effectively. In this paper, we distinguish LA literacy from feedback literacy. This is attributed to the technical features of the LA reports, where the data and visualizations impact the complexity involved in sensemaking (Shibani, Knight & Shum, 2022). For instance, students require foundational competencies of interpreting data visualizations, evaluating the trustworthiness of the report and source, making sense of the results in the learning context and taking follow-up steps to improve based on the insights gathered, while teachers require additional competencies to communicate with their students LA reports and groom them to be LA readers. While data literacy focuses on competencies involved in working with data, LA literacy in this paper distinguishes itself with its focus on using analytics as feedback for teaching and learning. Thus, we view LA literacy as an intersection between feedback and data literacy and, in this paper, define LA literacy as the ability to appreciate, critique, interpret and use LA effectively to gather insights on teaching and learning.

2.2 Micro-Meso-Macro (3M) analytical framework

In line with workshops held in previous years, frameworks such as Ogata et al's (2018) were developed and discussed to benefit learners in technology-enhanced and evidence-based studies. In this paper, we also seek to assist the development and propagation of LA literacy while allowing benchmarking of standards by tapping on a micro-meso-macro architecture that stemmed from an economic perspective (Dopfer et al., 2004). This paper proposes a framework that can handle emergent and complex systems as a population, structure, and process of rules. For usage with multilevel classification and within educational research, it has also been adopted and utilized as an analytical framework (e.g., Lee et al., 2022) for understanding and studying learning behaviors and relations on different levels and to explain interaction patterns, activities, and outcomes designed for the educational context.

In this paper, the 3M analytical framework (Figure 1) by Lee et al. (2022) was designed and expanded for inculcating LA literacy among the three levels of an educational ecosystem, due to how different levels of the framework were designed to address different scopes and fields of the educational spectrum. These levels were crafted from an institutional perspective, consisting of the effect and impact on individual agents (inclusive of teachers and students) at the micro level, the cross-class or intergroups and possibly institutional-wide implementation of LA literacy practices by educators and teachers at the meso level, and the likelihood of LA literacy programs being developed and conducted across institutions and potentially on an international scale at the macro level.

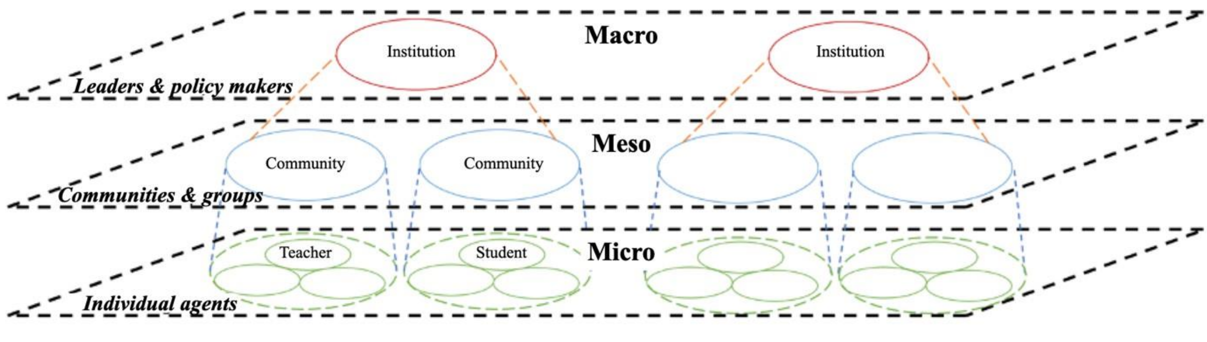

Figure 1. Micro-Meso-Macro framework for guiding LA literacy across institutes (Lee et al., 2022)

3. Enhancing and extending LA literacy across the different levels

Given that students' and teachers' LA literacy is influenced by the interplay between individual, contextual and organizational factors, it would be vital to consider cultivating LA literacy as the propagation of changes at different levels of an evolving ecological system (Dede, 2006). By leveraging the 3M framework (Figure 1), this section discusses how the push for LA literacy can be initiated and established at the respective micro, meso and macro levels to better coordinate LA practices within an education ecosystem.

Two vital themes are viewed to be necessary for the cultivation and support of LA literacy: raising awareness and raising criticality on the use of LA. As LA literacy is still not widely known in the education community, enabling the community to be more LA literate would require spreading the word on the need for cultivating literacy around the use of LA across different levels. Starting from the macro level, awareness of LA literacy can be initiated and raised, with resulting effects on the communities at the meso level and the individual micro-level agents. The second theme builds on the first theme by raising the criticality of using LA. In this theme, collaboration and communication across different groups of people across different levels are key to continuous efforts toward improving LA literacy. Through open channels of communication across communities, sustained exposure and participation in the use of LA will enable a deeper understanding of the common assumptions and pitfalls of LA, while at the same time increasing the appreciation for the role of LA in teaching and learning. The activities and interactions within and between the different levels of the 3M framework are exemplified in Figure 2, with details provided in the following sub-sections.

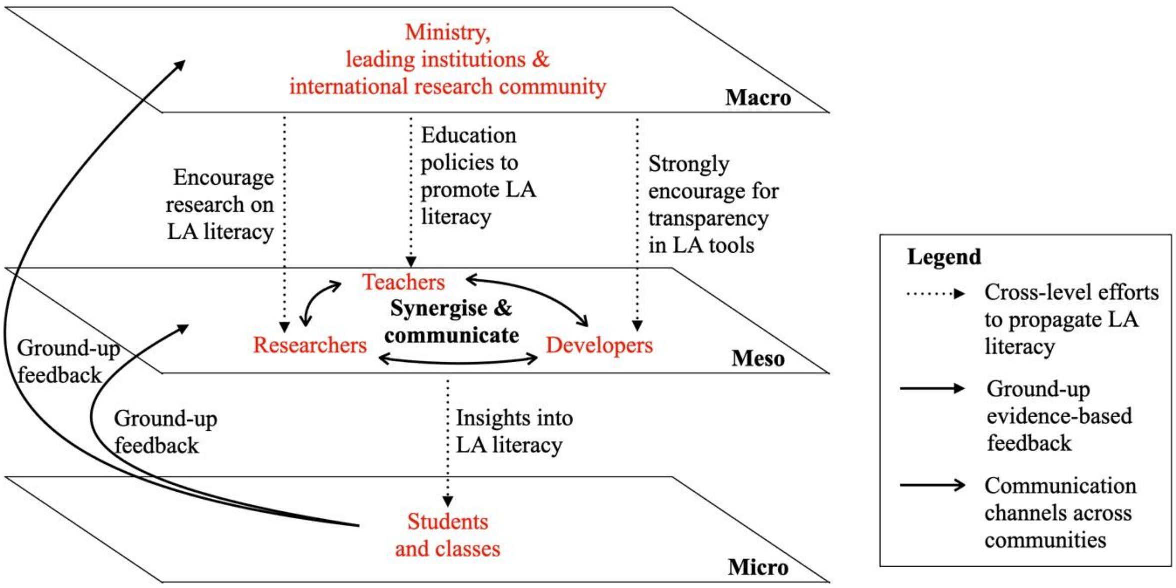

Figure 2. Activities and interactions that cultivate and support LA literacy in a 3M framework.

3.1 Macro level

At the macro level, the focus lies in the deliberate considerations over effective organizational moves and their resultant institute-wide effects. Recently, institutions and leading scholars decided to take significant steps toward a more ethical approach to safeguarding data providers, resulting in less effort and emphasis being placed on advancing stakeholders' competency in using LA. For instance, the Open University introduced eight principles in the Open University Policy to ensure the ethical use of student data for LA (The Open University UK, 2014). Other organizations and research communities followed suit, listing the responsibilities of institutions to ensure ethical LA (Sclater & Bailey, 2015) or creating checklists for ethical LA implementation (Drachsler & Greller, 2016). With huge steps already taken towards the ethical use of LA, more efforts could now be directed towards increasing the visibility of LA literacy and facilitating the motion towards cultivating LA literacy.

We anticipate that LA literacy at the macro level could be propagated via three channels. First, crafting education policies that necessitate the cultivation of LA literacy for teachers and students through the curriculum or learning activities will help raise awareness and the importance of LA literacy. Next, some funding support could be directed towards research efforts to encourage the characterization and design for cultivating LA literacy. Insights gathered from these research projects could then propel professional communities at the meso level towards more effective use of LA and address LA implementation concerns at the micro-level. Lastly, ministries and leading research communities can set up non-enforceable mandates to ensure higher transparency in the ecosystem of LA environments (i.e. infrastructure of the LA system, educational data used for LA and the development of LA tools. This can help reduce the likelihood of having black box systems that complicate the understanding and use of LA. LA developers could also be recast as guides to help stakeholders understand the developed tools.

3.2 Meso level

Entities at the meso level often encompass smaller communities and groups that are more agile and thus can be more flexible in the design and implementation of LA. The meso level can prioritise the open collaboration and communication between teachers, researchers and developers to support collaborative efforts toward developing interventions for cultivating LA literacy. Communities between different stakeholders are few, resulting in a lack of communication channels for intra- and inter-community discussions. The goal at the meso level is to forge a tripartite relationship where educators provide insights on learning experiences and the delivery of intervention, researchers provide theoretically grounded considerations and empirically validated approaches for comparative interventions, and LA developers provide technical expertise in the design and construction of technology and tools to support LA literacy. For instance, funded by the European Commission, Learn2Analyze (L2A) was created to forge an Academia-Industry Knowledge Alliance consisting of an international group of eLearning market leaders and educational data analytics academic teams to improve the community's competencies in the use of LA.

Open dialogues among teachers, researchers and developers should be encouraged, and these communication channels should also be sustained to raise the stakeholders' criticality towards using LA. The community of teachers, researchers and developers will be able to generate a knowledge base of insights into LA literacy, instructional strategies and pedagogical designs that we can further tap on to improve LA literacy for the education community.

3.3 Micro level

The micro level constitutes agents, with uneven attention predominantly centred on the students due to easily recognisable outcomes based on learning metrics and the subsequent effect sizes. The micro level focuses on testing implementation designs created to improve students' and teachers' LA literacy and to gather insights into their responses to these interventions. The pedagogies and LA tools that were developed at the meso level can be trialed in classrooms, and empirical data will be collected and analysed to measure the effects and impacts of the interventions on their LA literacy. This form of data provides critical feedback from the ground-up for further revisions to the designs at the meso level and assists the calibration of policies and funding directions at the macro level. As an iterative and cyclic process, it also completes the feedback loop for continued and sustained improvements for stakeholders like teachers and students.

4. Conclusion and Future work

In a nutshell, the field of learning analytics has progressed significantly over the past decade and has greatly benefited various stakeholders involved in teaching and learning processes. However, the amount of underlying work and efforts exhibited by stakeholders should be given more attention to avoid giving false impressions of LA being an all-round enabler with advantages without clear downsides. To guide this understanding, we propose the use of a 3M framework to highlight the importance of cultivating and supporting LA literacy for a better understanding of teaching and learning practices and further suggest how a systematic implementation of raising LA literacy can be conducted via the two themes of raising awareness and raising criticality. This paper has focused on the need to cultivate LA literacy amongst education stakeholders as an approach to increase the effective use of LA. Details of the characteristics of LA literacy and the pedagogical designs in supporting LA literacy will be further examined in future work. We hope this paper can accentuate the need for LA literacy and encourage more researchers to articulate strategies and models to support LA literacy.

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Repurposing Existing Data Towards Institutional Learning Analytics: A Review of Outcome-mapping Data of HEIs in India

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Abstract: The paper addresses the possibility of repurposing existing data structures in Indian higher education institutes (HEIs) for the deployment of institutional learning analytics (LA). To that end, the paper critically reviews the kind of data that HEIs in India already generate for quality control and accreditation by the National Assessment and Accreditation Council. It argues that, albeit with caveats, existing data structures of programme and course outcomes maintained by HEIs can be repurposed toward institutional LA deployment. A significant amount of work must be done to flesh out the learning theories that will inform the data structures. Centring learning outcomes for LA deployment can help address the various existing critiques of LA. At the same time, outcome-based approaches risk expunging unexpected, abstract and social learnings and risk reproducing managerialist approaches to education.

Keywords: creative data sourcing, institutional learning analytics, quality assurance in higher education, India

1. Introduction

Institutional deployment of learning analytics is at a nascent and embryonic stage in India. This trend reflects the broader lack of LA research and practice in the global south. Various possible reasons for the lack of LA research in the global south have been noted including lack of infrastructure, possible under-reporting of experiments, initiatives and publication of research in non-indexed avenues (Guzmán-Valenzuela, Gómez-González, Rojas-Murphy Tagle, & Lorca-Vyhmeister, 2021).

Guzmán-Valenzuela et al. (2021) limit the infrastructural lack to technologies that facilitate “the promotion of more virtual and blended learning within…universities which, in turn, generates possibilities for data management systems and, thence research" (Guzmán-Valenzuela et al., 2021, p. 12). This equation of LA with online learning has been noted to be one of the significant deficiencies of the existing approaches of LA, as Eradze, Väljataga, & Laanpere (2014, p. 256) note, “most of the tools for gathering the learning analytics data are directed to the closed LMS systems, while most of the learning happens outside the LMS”.

Thinking about the lack of infrastructural lack in the global south, certain authors have called for creative data sourcing strategies (Gašević, 2018). Echoing the principle of data minimization Prinsloo (2018) warns against the rampant call for indiscriminate data collection. The paper builds on such calls for creative data sourcing strategies in the global south to address the viability of repurposing existing quality control and accreditation data which is currently generated by HEIs in India.

HEIs in India, generate a significant amount of data for quality control purposes for the National Assessment and Accreditation Council (NAAC). Though NAAC accreditation remains a voluntary affair, institutions seek NAAC accreditation for consumer assurance in an increasingly privatized higher education sector. The data generated for NAAC retains the methodological limitations of the NAAC-mandated methodology. The paper argues, albeit with caveats, that an evaluation of the outcome-based mapping of programmes and courses and the pedagogic methods can form the ground for an institutional LA deployment. While noting that, the paper also flags the limitations of an outcome-based approach and the limitations of the current data collection methodologies.

2. Existing Work

The paper follows existing literature concerning LA in the global south which has called for "connectedness within local systems and across levels of a system" (Chen & Fan, 2018, p. 41) and comprehending the nature of data that is already being generated and collected (Prinsloo, 2018). These calls have been made amidst the steady adoption of ICTs and the risk of HEIs adopting "commercial providers and platforms" (Prinsloo, 2018, p. 30).

Gašević's call for "creative data sourcing" (2018, p. 8) is a valid call amidst such a context as Prinsloo notes the solution "may not be to harvest more (or different) data" (Prinsloo, 2018, p. 29). We take Gašević's and Prinsloo's calls, for creative data sourcing and mapping the nature of existing data, seriously to grasp the kind of data that HEIs in India are already generating. for quality control, assurance and accreditation purposes.

The NAAC was set up in 1994. Though accreditation by NAAC is not compulsory and remains a voluntary affair as an autonomous body under the aegis of the University Grants Commission (Stella, 2004, 2015). NAAC's accreditation is a much sought-after metric by a third party in an educational landscape which is populated heavily by private and non-state actors. NAAC's process seeks to enable quality control and provides comparative quality indices at the national level that is used by students and parents to make decisions about enrolment into colleges and universities.

The existing NAAC methodology seeks to provide accreditation to HEIs and mandates the institutes to set up an internal quality assurance cell (IQAC) to proactively engage in quality control measures. This internal quality assurance mechanism is complemented by a peer-review of the institutional reports submitted during the accreditation process whose scores remain valid for five years. The existing NAAC methodology remains skewed towards institutional accreditation over departmental accreditation.

In a recent whitepaper published by NAAC, Patwardhan et al. (2022) argue for a massive overhaul of the existing NAAC methodology away from an input-based system to an output-based system. They argue for a "shift from the current fixed time-point data entry…and peer team visit based summative assessment system…to capture real-time data and continuous assessment of education quality and expected outcomes" (Patwardhan et al., 2022, p. 58). Patwardhan et al. (2022) also call for a refocusing on learning outcomes (LOs) rather than focusing on other proxies, as they note "quality of teaching-learning is currently assessed by proxy parameters like teacher-student ratio, number of PhD holders in the Faculty, number of books in the library, and so on" (Patwardhan et al., 2022, p. 37).

The speed and the specifics of the transition remain uncertain at the moment. Hence, the paper follows Gašević's call for "creative data sourcing" to ascertain if the existing data being generated for the NAAC can be repurposed for the institutional deployment of LA while centring LOs. The paper also builds on existing works which have argued for existing data being generated for the NAAC toward output-based education (Amirtharaj, Chandrasekaran, Thirumoorthy, & Muneeswaran, 2022).

3. Methodology

To gain familiarity with the existing data structures that HEIs generate and manage in India, the standardized data template used by HEIs to submit data to NAAC was referred to. Following this, self-study reports (SSR) submitted by HEIs to the NAAC were referred to critically assess the granularity of data concerning learning processes and outcomes. Additional documents and data submitted with the SSRs were referred to understand precisely the nature of data currently present with HEIs concerning learning outcomes and processes.

4. Repurposing NAAC data for institutional LA deployment

4.1 Nature of Data Generated for Accreditation by the NAAC

HEIs in India generate a significant amount of data for the accreditation process for the NAAC. Institutions which have gone through multiple cycles of accreditation have an IQAC in place which manages the generation of data for the accreditation and quality assurance process. The NAAC publishes a manual (National Assessment and Accreditation Council, 2018) for generating SSRs. The presence of the manual has led to a standardization of reports being generated by HEIs (Stella, 2015). The SSRs include a range of information and data about the HEIs. They often include additional documents which provide further details about the institutions at a granular level.

Various kinds of data and information are present in each of the above criteria of assessment. For heuristic reasons and a lack of space, Table 1 summarises the assessment criteria and their sub-division to provide the reader with a sense of the diverse range of data HEIs in India currently generate. Each of the sub-criteria provides qualitative and quantitative data and information of various kinds. The quality of the information provided often differs depending on the institution.

Table 1. *Some of the criteria of assessment and their subdivisions and their weightage in SSRs relevant for LA deployment.* (National Assessment and Accreditation Council, 2018).

Criteria of assessment	Sub-criteria	Weightage on a scale of 1000 points
Curricular Aspects	1.1 Curriculum Design and Development	50
	1.2 Academic Flexibility	50
	1.3 Curriculum Enrichment	30
	1.4 Feedback System	20
Teaching-Learning and Evaluation	1.1 Student Enrolment and Profile	10
	2.2 Catering to Student Diversity	20
	2.3 Teaching- Learning Process	20
	2.4 Teacher Profile and Quality	50
	2.5 Evaluation Process and Reforms	40
	2.6 Student Performance and Learning Outcomes	30
	2.7 Student Satisfaction Survey	30
Student Support and Progression	5.1 Student Support	30
	5.2 Student Progression	40
	5.3 Student Participation and Activities	20
	5.4 Alumni Engagement	10

Each of the above sub-divisions provided in Table 2 can form the ground for an institutional LA deployment. One of the persistent critiques of LA has been LA's lack of focus on educational and learning theories (Guzmán-Valenzuela et al., 2021). It is hence, pertinent to begin an institutional framework for LA deployment which starts with a focus on learning processes while at the same time acknowledging the limitations and genealogies of the above data and their rationale.

4.2 An Illustrative Case

In point no. 2.6 (from Table 1), institutions provide detailed information about the curriculum, assessment and learning outcomes methodology of the institution. Institutions are offered an option to share a detailed description of programme outcomes (PO) and course outcomes (CO) and how they are linked to graduate attributes. This detailed mapping of POs and COs then is a task which has already been undertaken by most institutes which have gone through multiple cycles of NAAC accreditation.

Consider a programme of Bachelor of Architecture from an HEI in Bengaluru. The institute provides all of the department's data in the public domain for NAAC accreditation. The Bachelor of Architecture at the HEI under consideration defines the graduate attribute as: "The B Arch Programme intends a deep immersion in an ecosophical perspective of architecture, as part of an inspired understanding of larger discourses: environmental, social, political, artistic and technological".

The data lists the range of programme outcomes divided into three groups, affective, cognitive and psychomotor components. Along with the programme outcomes it maps each course in the programme to the various programme outcomes with the adjacent mastery level mapping. Each course is valued and classified on a three-tier mastery scale: introductory, reinforced and emphasized. For each course outcome and its mapping to programme outcomes the data sets also list out instructional and assessment strategies that are deployed.

Consider for example PO1 of the programme under consideration: "Sensitize students to be socially and environmentally responsible and to work effectively in multi-disciplinary teams within the field of human habitat" as an affective component. In the course Discovering Design from Semester 1, PO1, among others, is classified with mastery level being "introductory". The instructional strategies deployed towards the course outcome are "Studio on Wheels, Lectures, Presentation, Mapping, Film watching, Workshop and Masterclass" while the assessment strategies mobilized include "Pinup reviews, Individual Desk Crits, Group Discussion and Portfolio Submission".

Similarly, the course Specifications, Estimation and Costing of Buildings from Semester 5 aims at a mastery level of 'emphasized' for PO3 which is, "Nurture quality education that enables use and extension of appropriate knowledge for designing built environment" classified as a cognitive component. The instructional strategies include "Lectures, Discussions, Active problem-solving in class" while the assessment strategies include "Assignments, Examinations".

Amirtharaj et al. (2022) provide a view of what the outcome-based approach looks like from the perspective of instructors, teachers, evaluators and administrators in an HEI in India. The COs and POs are quantified for each student at different scales from the individual, across courses to the programme. One particular course, for example, could have more than one CO. As per Amirtharaj et al. (2022) a student is scored not just on the whole course as such but each COs are scored as well. While such granular level mapping of COs and POs is followed, the cycle for assessment of CO and PO attainment is relatively large. They list the frequency of assessment processes as follows:

- "CO–PO mapping—Every year (for each course);
- CO attainment report—Every year (for the three internal tests, assignments and end semester examination);
- PO attainment report—Once for every batch (after course completion);
- PEO attainment report—Once for every batch (after course completion);
- Alumni feedback—After graduation;
- Parents feedback—After graduation of their wards;
- Placement (including campus recruitment) record—Every year; and
- Employer feedback—Occasionally." (Amirtharaj et al., 2022, p. 22)

It is worth noting the fact that such a low frequency of CO and PO attainment reports inevitably leads to a relatively non-dynamic system. For a dynamic LA system, a real-time overview of CO and PO attainment will be a necessary update to the existing system to locate precisely the divergent outcomes of pedagogic methods, instructional strategies or evaluation strategies. An increase in the frequency of attainment report assessment or real-time monitoring of CO and PO attainment would require significant organisational changes. Amirtharaj et al. (2022) list out a series of organisational structures which allow for reconfigurations to take into account the CO and PO attainments. While at the top of the organisational structure remains the Board of Studies, the lower-level ranges from class monitoring committee meetings and faculty council meetings. A robust LA strategy would require formalizing to an extent and empowering individual teachers to conduct pedagogic experiments and changes to ascertain different strategies. The current organisational structure remains relatively bureaucratic and slow to effect change.

Another important aspect that requires flagging is that the existing documentation exercise for NAAC has been noted to be "too intensive and overwhelming for the HEI and must be rationalized and reduced if possible" (Patwardhan et al., 2022, p. 38). While the documentation exercise and the necessary data entry could be automated through learning management systems if efficiently deployed, one can also foresee an increased workload on teachers if the organisation is unwilling to reskill its existing labour force or hire a new workforce in place of the work that was automated. If real-time data collection of CO and PO attainment becomes another chore in the long list of tasks that teachers have to do, the quality of the data and deployment of such new approaches will remain suspect.

4.3 Limitations of Existing Data and Outcome-based Approaches

As already noted, the frequency of data collection is relatively low currently. Call for additional granular data about learning processes and outcomes can only be effective if organisational changes are implemented to make them more dynamic. The current organisational mechanisms noted by Amirtharaj et al. (2022) are relatively bureaucratic. Division of existing COs and POs through tools such as Bloom's Taxonomy has been noted to be an effective method of curriculum review to identify tasks where students face hurdles (Teater, 2011). Such meta-classification of COs and POs remains a possible approach to the granular mapping of COs and POs.

While granular data ontologies taking into account LOs remains a possible positivist route, it is also important to flag the limitations of such an approach. Constructionist critiques of learning outcome-based education note that "LOs that are expected to be full-ended and predefined" (Havnes & Prøitz, 2016, p. 219) efface unexpected learning, learning from peers and social surroundings. They also note that "some knowledge may be difficult to specify due to their level of abstraction" (Havnes & Prøitz, 2016, p. 208) and warn against the managerialist tendencies of outcome-based approaches.

5. Conclusion

The field of LA has been noted to be lacking in engagement with educational and learning theories, most often resorting to proxies of learning processes to measure learning. At the same time, authors inspired by the field of critical theory have pointed towards fundamental risks of LA, with increased surveillance, racializing drives of artificial intelligence and machine learning while others have noted the production of new social orderings through fundamental methodological choices of LA. A significant amount of work, going forward, needs to be done to flesh out the learning theories which shall inform the data structures for LA deployment. The current CO and PO mapping and the usage of mastery levels reflect a genealogical trace of work by Benjamin Bloom for example.

By beginning our work on LA, from COs and POs i.e., by centring learning outcomes, we wish to address the existing lacunae in the field of LA which has tended to work without a strong focus on education and learning theories. By focusing on existing data collection, we could reconfigure existing methodologies for LA deployment while addressing the limitations and flaws of the existing data methodologies. By centring on learning outcomes and processes, we also hope to reduce the stress on demographic data. Coupled with that, an acknowledgement of the limitations of LOs and LA will allow for differential student trajectories and non-normative learning behaviours to be accounted for.

6. Limitations and Future Work

The SSRs generated for the NAAC also include information about learning management systems (LMS), their usage and deployment. Information concerning LMS usage in the reports across institutions is very inconsistent. While most institutions suggest the usage of LMS, only a few institutions report in detail the range of LMSs and the nature of their usage. A thorough mapping of LMSs across the country would provide us with much-needed insight into the baseline conditions across various HEIs. The nature of the data in HEIs in India, whether they can be represented in xAPI for example (Bakharia, Kitto, Pardo, Gašević, & Dawson, 2016), would also need to be surveyed and understood. While thinking through LA deployment at a trans/inter-institutional scale it is also important to ascertain the technical and policy context of interoperability of learning records. But it is important at the same time to acknowledge the limitations of LMSs and to think of learning analytics in an offline context. Further experiments with outcome-based education and data-based reconfiguration of the existing approaches would also need to be done to ascertain data ontologies for an LA informed by educational and learning theories while taking into consideration the privacy of the human actors.

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Modeling Students' Ability to Recognize and Review Graded Answers that Require Immediate Attention

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Abstract: Students utilize various resources to prepare for an examination, such as lecture materials, homework, or previous quizzes or tests. Reviewing graded tests allows students to develop their metacognitive skills. However, a lack of proper guidance, exacerbated by a lack of maturity, hinders fully realizing the benefits of learning from past mistakes. In this paper, we investigated students' reviewing strategies. We analyzed the clickstream data of students taking a Computer Science Education course. Using Hidden Markov models (HMMs), we modeled the reviewing behaviors of high-performing and low-performing students. Our preliminary findings suggest that the two groups share some similar strategies but also have some that are particular to the group.

Keywords: Reviewing behavior, clickstream data, hidden Markov models

1. Introduction

Students prepare for examinations using various resources that are made available to them. In an earlier survey, students indicated that apart from lecture materials, they also reexamine previous quizzes or tests (Paredes et al., 2017). Students used it as a practice opportunity anticipating that a similar question would come out in the examination. Reviewing assessments enables students to demonstrate and enhance their metacognitive skills, such as monitoring mistakes or evaluating a learning strategy's success and adjusting if necessary. Knowing how they performed in a graded assessment allows them to formulate a plan to address their misconceptions.

This paper aims to determine whether students can identify the questions that require their immediate attention. *Do students review questions based on their performance? What reviewing patterns can be uncovered?* These questions can be answered by looking at how students interact with an educational technology that captures their reviewing behaviors. These strategies are captured in the form of clickstream data. Many approaches can be employed to model and interpret such behaviors. In this paper, we modeled students' clickstream behaviors using Hidden Markov models (HMMs) and presented our preliminary findings.

2. Related Work

Earlier works have examined the distribution of the students' review actions and how this affects their succeeding examination performance (Paredes, Azcona, et al., 2018; Paredes et al., 2019). Moreover, when students review their graded tests, they benefit from being guided in identifying which items to focus on (Paredes, Hsiao, et al., 2018). However, these earlier investigations did not consider the dataset's sequential and temporal dimensions. The analyses focused only on the frequency of user actions and did not account for the transitions between them. Therefore, this current work aims to address the said limitation.

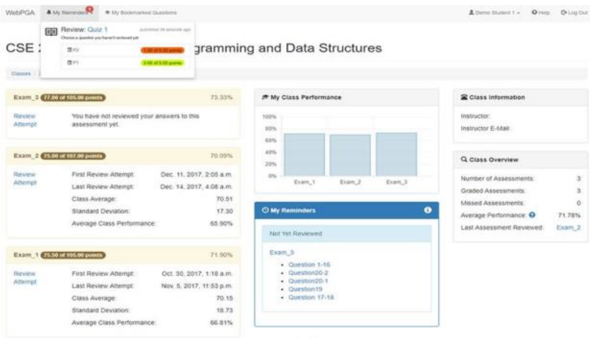
HMM is among the popular approaches to analyzing and modeling clickstream data (Rabiner, 1989). Beyond the educational data mining domain, many works have leveraged this technique to understand behavioral patterns (e.g., common transitions as visitors navigate an e-commerce website; Liu et al., 2017). An advantage of this approach is that it incorporates the temporal information of the data as opposed to simple clustering (Perera et al., 2009).

3. Methods

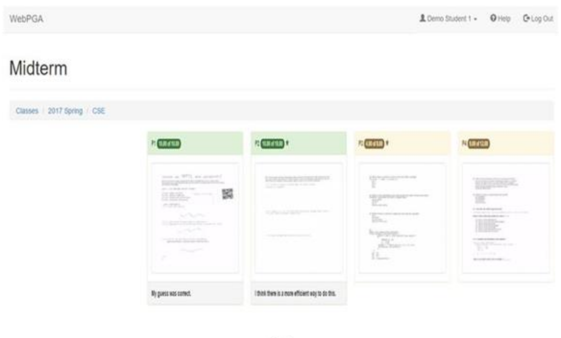
3.1 Data Collection

We analyzed a total of 88,111 actions from clickstream data of 317 students enrolled in an Object-Oriented Programming and Data Structures class. These interactions were captured using the educational tool WebPGA (Paredes et al., 2019). The course had a total of 17 paper-based assessments. Three of them were examinations, while the other 14 were quizzes. Two of the quizzes were for credit, while the rest were not. Students had to answer these quizzes and were awarded full points regardless of the correctness of their answers, as these were used for attendance.

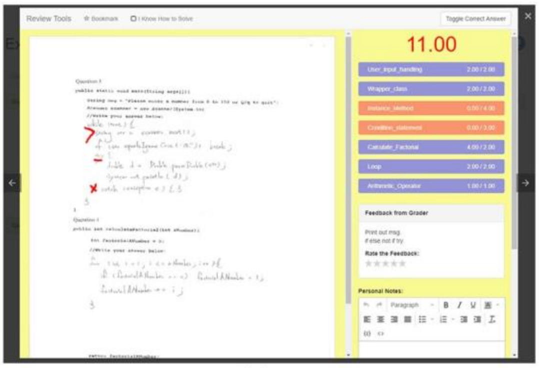
Although the system can capture multiple student interactions, we limited this preliminary analysis to three specific actions. These actions represent the three levels of how a student can review an assessment as illustrated in Figure 1. The first level is the *dashboard* or *class overview* (Figure 1a), where students are presented with a list of all the assessments administered in class and the scores they obtained. The second level is the *assessment overview* (Figure 1b), where students are shown all the questions from the selected assessment. Their scores for the individual questions are shown at this level. From here, students can choose a question to review, which leads them to the third level or the *question overview* (Figure 1c). Students can see fine-grained information about the question in the third level, such as the rubrics used to assess their answer, detailed feedback from the grader on why such a score was given, and written annotations on the digital paper.



(a)



(b)



(c)

Figure 1. Screenshot of the various levels how a student can review an assessment: (a) dashboard or class overview, (b) assessment overview, and (c) question overview

3.2 Data Pre-Processing

The students used the platform throughout the semester at their convenience. They were informed via announcements in the learning management system (i.e., Blackboard) immediately after an assessment was graded. Each student's overall performance was computed by averaging the student's scores in the three examinations. Lastly, students were classified as *high-performing* or *low-performing* using the class average (M=0.83, SD=0.12) as the cut-off point.

Each question had varying difficulty. To determine this, we examined how the entire class performed. The average score for all the answers to a question was computed. The higher the value, the easier the question is. We used this information to add context to the reviewing behavior of the students. We compared the score obtained by the student to the question's difficulty. If the student obtained a higher score, a review action on this graded answer was labeled a *non-urgent question review*; otherwise, it was labeled an *urgent question review*. The rationale behind this heuristic is that students should attend to the questions they did not satisfactorily do the soonest.

Each student is represented by a single sequence enumerating the various actions performed on the system. The system can identify a group of actions performed in a single session. Therefore, a symbol was introduced to indicate the beginning of a new session. The average sequence length was 125 actions. Table 1 provides a summary of the various symbols used for the analysis.

Table 1. *Symbols used to represent the various actions performed by the students*

Symbol	Description
D	Viewing the class dashboard that shows an overview of the student’s scores on all the assessments.
A	List all the questions of an assessment and the scores obtained by the student in each question. Allows them to choose a question to review in detail.
N	Reviewing a graded answer considered non-urgent. The student's score is above the threshold based on the question's difficulty.
U	Reviewing a graded answer considered urgent. The student's score is below the threshold based on the question's difficulty.
X	Reviewing an ungraded question. The question's difficulty is unknown.
S	Used as a marker to denote the beginning of another session in the student's sequence.

3.3 Hidden Markov Model

One common approach to modeling sequential data is through HMM (Rabiner, 1989). We developed two HMMs to model the sequences of the two student groups, one for each group, and explore any similarities. The number of hidden states (HS) was a parameter that needed to be estimated. The parameter was set to four based on a similar early work where the Akaike Information Criterion (AIC) was used to determine the optimal number of hidden states (Hsiao et al., 2017). As shown in Table 2, each HS represents a strategy where the emission probabilities of each action are identified. The most probable action of a strategy is highlighted. Essentially, an HS encapsulates the combination of actions that are likely to be done by the student. The transition probabilities between strategies (HS) of the two models are illustrated in Figure 2. Due to the system's design, the prior probability of the HS1 for both models is 1.00. It simply means that all sequences always begin with navigation from the dashboard.

Table 2. *The Emission Probabilities of the Two HMMs*

Group	Strategy	D	A	N	U	X	S
High	HS1	**0.70**	-	-	-	-	0.29
	HS2	-	**0.95**	-	-	0.03	0.03

	HS3	0.21	0.06	0.21	0.16	**0.36**	
	HS4	-	0.15	**0.63**	0.22	-	-
Low	HS1	**0.59**	0.12	0.01	-	0.28	-
	HS2	-	**0.79**	0.09	0.12	-	-
	HS3	0.09	**0.60**	-	-	0.04	0.27
	HS4	0.03	-	0.31	**0.66**	-	-

Note. Values less than 0.01 were omitted.

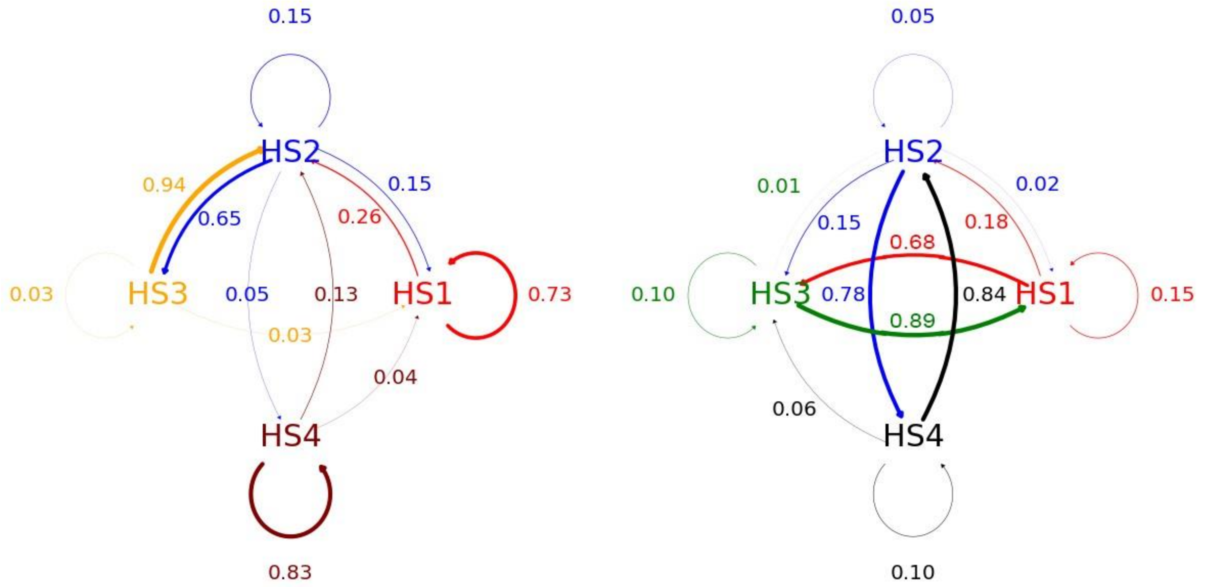


Figure 2. The transition probabilities of the two HMMs: high-performing students (left) and low-performing students (right), both with four hidden states (HS), each representing a strategy

4. Preliminary Findings

Based on how the system was design, a typical workflow always begins with the class dashboard (Figure 1a), where students choose an assessment to review. Afterward, students choose a particular question to review (Figure 1b). Students can navigate to the next question using the next or previous buttons; or close the current question window, go back to the assessment overview, and choose another question from the list (Figure 1c). The system has a personalized notification panel on the top and is always visible regardless of where the student is. It enables students to navigate directly to specific questions not yet reviewed.

The hidden states reflect the students' reviewing strategies. As evident in the two groups' prior probabilities, students would always start their review from the dashboard. However, the high-performing group's emission probability for the HS1 strategy is limited only to actions D and S. This means they do not go into the details of any assessments at that moment. On the other hand, the HS1 strategy of the low-performing group shows more actions aside from the dashboard. They would go ahead and review ungraded questions. This action by the low-performing group could indicate that they were using the notification panel.

High-performing students are likely to repeat their HS1 strategy of checking their overall performance from time to time. However, there are instances where they would change strategy and go into the details of an assessment, then later details of various questions as evidenced by their transition from HS1➔HS2➔HS3. Interestingly, in their HS3 strategy, the emission probability is high on ungraded questions, which suggests that they exert effort to review questions that were not graded to help them prepare for an exam. The loop in HS3➔HS2➔HS3 indicates that these students consciously determine which questions to review next instead of simply relying on the built-in navigation buttons. It possibly suggests the ability of these students to recognize which of their graded answers to review next. This strategy could be a potential indicator of the student's awareness of planning on how to address their misconceptions. The HS4 strategy, which focused on reviewing the non-urgent questions, had a lower likelihood of happening since the only way to reach HS4 is through itself or from HS2.

Low-performing students, like the high-performing students, had a high probability of transitioning to a strategy involving the assessment overview, HS2 or HS3 (more probable). A closer look into the more probable transition HS3 strategy's emission probability shows the presence of seeing the session marker. It suggests that these students often stopped reviewing at the assessment level and did not proceed further to the question level. It is even more pronounced in the following transition of HS3➔HS1➔HS3, meaning they would only log in to the system to check their scores without the intention of knowing where they made mistakes or learning from the feedback provided by the grader. The strategy for reviewing questions, particularly urgent ones, in detail HS2➔HS4➔HS2 involves a loop. These states can only be reached from the HS1 strategy.

5. Limitations and Future Work

This preliminary work aimed to model students' ability to recognize questions requiring immediate attention as they review and prepare for an upcoming examination. It also investigated whether the two student groups had different strategies in this process. One of the limitations of this analysis involves estimating the parameters of the HMM. Although we followed the AIC method, several approaches can be explored that use information from the data. For example, Li and Biswas (2002) proposed a Bayesian approach to estimate the number of hidden layers based on the data.

Two other approaches to analyzing sequential data include clustering students who had a similar distribution of actions they performed. Another is leveraging sequential pattern algorithms (e.g., Generalized Sequential Pattern; Srikant & Agrawal, 1996) to identify frequently performed actions. Differential pattern mining (Kinnebrew et al., 2013) which focuses on sequences specific only to certain student groups, is also a promising direction. Finally, instead of focusing on what actions are frequently performed on the system, another perspective is to examine each student group's distinct actions.

The clickstream data used in this study focused only on what was available on the system. This data can be used to complement other clickstream data available from other systems, such as learning management systems. In effect, it would allow for a better understanding of the students, as shown in the work of Gitinabard and colleagues (2019). With the shift of most activities to online due to the Covid-19 pandemic, it would also be worth investigating whether similar trends can be found in assessments administered electronically.

The current models can be incorporated into the system, allowing future studies to investigate whether students would benefit from a personalized intervention to improve their reviewing behaviors. By analyzing the students' clickstream data in real-time, tailored suggestions in the form of notifications can be shown to students, making them aware of their current strategy. The same can also be used to make them understand the strategies of successful students, hopefully enabling other students to emulate such behaviors.

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Automated Test Set Quiz Maker Optimizing Solving Time and Parameters of Bayesian Knowledge Tracing Model Extracted from Learning Log

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Abstract: Creating a set of quizzes for the students' test is almost an irreplaceable task to teachers. In practice, a teacher could use a learning analytics dashboard while creating a test to control the quiz difficulty and the amount of time it takes to solve. This paper draws inspiration from this practical example, and we propose an automated test set quiz maker by optimizing the time and learning parameters that have been estimated from the analysis of learning logs. First, we estimate the Bayesian Knowledge Tracing (BKT) model parameters: in particular the guess and slip probability from the quiz answer log history. The system automatically generates a test set of quizzes if the user inputs the desired amount of time it should take to solve the test by optimizing the selection of quizzes based on BKT parameters and estimated solving time. This function is expected to reduce the burden of preparing examination questions for teachers, and it can be used as a trial test before the exam for students.

Keywords: Automated test set quiz generation, Bayesian Knowledge Tracing, Mathematical Optimization, Knapsack Problem

1. Introduction

Learning Analytics (LA) is an emergent field and its aims are better understanding of students and providing intelligence to students, teachers, and administrators using learning log data (Law & Liang, 2020). In school practice, teachers use learning log data to monitor students' learning status, including their study time and percentage of correct answers through a dashboard (Majumdar et al., 2020). In particular, Mr. Miyabe, an experienced junior high school math teacher, practices creating exam questions by controlling answer time and difficulty level based on the percentage of correct answers to questions for the entire class obtained from the dashboard. He said 'Until now, when creating test questions, average scores and answer times were estimated "based on teacher experience". By using the analysis dashboard tool, even inexperienced teachers can easily do this and reduce the time required to create test questions'. Inspired by this practical example, we propose an automated test set quiz maker by optimizing time and learning parameters from learning log. The system is expected to be used at schools to create exam questions based on students' learning history (students' comprehension and time spent answering quizzes) reducing the burden on teachers if the correct answer rate and answer time can be controlled and the optimal set of quizzes can be presented automatically. Students can also use the same feature to practice before an upcoming exam.

2. Related work

2.1 Learning Analytics

Learning Analytics (LA) is an emergent field which aims at a better understanding of students and providing intelligence to learners, teachers, and administrators using learning log data (Law & Liang, 2020). LA has been used in Higher Education for improving the services and students' retention rate (Bienkowski et al., 2012). Although most LA studies were conducted in higher education (Li et al., 2015), LA research has recently been spreading to K12 as well (Aguerrebere et al., 2022).

2.2 Testing effects

The testing effect also known as retrieval practice, active recall, practice testing, or testenhanced learning (Dunlosky et al., 2013; Roediger & Butler, 2011) suggests devoting part of the learning period to retrieving information from memory increases long-term memory (Bruce Goldstein, 2010). For example, Roediger and Karpicke (Roediger & Karpicke, 2006) asked participants to study two sentences, with one sentence studied twice and the other studied once and tested once. One week after a test, the tested sentence was better recalled than the restudied one. The testing effect has been demonstrated in numerous studies using different educational materials in both laboratories and classrooms (Roediger & Karpicke, 2006; Rowland, 2014). Testing is an effective way to learn, but it requires a great deal of teacher knowledge and effort to create a set of quizzes for the test.

In this study to reduce the teachers' burden of creating tests, we propose an automated test set quiz maker by optimizing time and learning parameters from learning log. This research will develop a function by not creating a new quiz one by one but by developing a function that uses mathematical optimization to select the optimal quiz set from already created quizzes. Namely, this function automatically generates the test set of quizzes if the user inputs the desired amount of time it should take to solve the test by optimizing the selection of quizzes based on BKT parameters and estimated solving time.

3. Methods

3.1 System overview

The automated test set quiz maker proposed in this paper was plugged into the recommender system on the LEAF framework. LEAF framework is an infrastructure system to support the distribution of learning materials, collection and automated analysis of learning behavior logs in an open and standards-based approach (Flanagan & Ogata, 2018). The main components of the framework are: Moodle LMS which acts as a hub for accessing various courses; the BookRoll reading system for learning material and quiz exercise distribution; an LRS for collecting learning behavior logs from all of the components; and the LAView learning analytics dashboard to provide feedback to students, teachers and school administrators. This framework enables us to collect and analyze learning behaviors in real time and provide feedback to stakeholders. Quiz books used in the mathematics classes were uploaded to BookRoll and multiple-choice quiz questions were created to enable the collection of answers in learning log data. The BKT recommender (Takami et al., 2021, 2022) was developed on the LEAF framework and automated test set quiz maker was plugged into the recommender as one of function recommendations.

3.2 Bayesian Knowledge Tracing algorithm

The Bayesian Knowledge Tracing (BKT) algorithm functions as a Hidden Markov Model (HMM) in its traditional form and assumes a student's knowledge as a binary variable showing whether or not a student has mastered a skill (Corbett & Anderson, 1994). This model calculates the probability of a skill at a given point in time by combining data on the student's performance up to that point with model parameters. The guess (giving a correct answer despite not knowing the skill) and slip (knowing a skill, but giving a wrong answer) parameters of BKT for each quiz are calculated from the data of correct and incorrect answers for all quizzes for all students in the relevant course using Python Library of Bayesian Knowledge Tracing Models (Badrinath et al., 2021).

3.3 Problem formalization as a Knapsack Problem

The knapsack problem is a problem in combinatorial optimization. It derives its name from the problem faced by someone who is constrained by a fixed-size knapsack and must fill it with the most valuable items. The knapsack problem has various kinds of practical applications i.e. portfolio optimization, cutting stock problems, scheduling problems (Martello & Toth, 1990) and cryptography (Chor & Rivest, 1988; Goodman & McAuley, 1985; Laih et al., 1989). In a given set of n items, each with a weight w_j and a value p_j, determine the number of each item to include in a collection so that the total weight is less than or equal to a given limit and the total value is as large as possible. the problem may be mathematically modeled as follows:

$$\text{Maximize } \sum_{j=1}^{n} x_j p_j$$

$$\text{Subject to } \sum_{j=1}^{n} w_j x_j \leq C \quad x_j \in \{0,1\},\ j = 1,...,n.$$

where x_j takes values either 0 or 1 which represents the selection or rejection of the ith item.
We put BKT model parameter or correct rate into a value p_j and quiz solving time into weight w_j in a given set of n quizzes constrained desired time to solve as C. We used python package *pulp* for optimizing.

3.4 Maximizing Guess and Slip value of BKT calculated from all of the course students

First, the guess (giving a correct answer despite not knowing the skill) and slip (knowing a skill, but giving a wrong answer) parameters of BKT for each quiz are calculated from the data of correct and incorrect answers for all quizzes for all students in the relevant course using Python Library of Bayesian Knowledge Tracing Models (Badrinath et al., 2021). The parameters of guess and slip are estimated using all logs of the course every hour and updates them every hour. Therefore, the parameters will continue to be updated until the actual day of the test, and quiz can be selected according to the latest state of understanding just prior to the test.

For guess value, we reported the first quiz in a component in a quiz book tends to be higher guess value because students haven't acquired the skills yet, and the quiz of acquiring a skill and then using that skill tends to be lower guess value, using an acquired skill, and therefore they are not guessing (Takami et al., 2021). From this study, we can consider lower guess value quizzes are difficult to be solved requiring basic skills. Therefore, in order to select difficult quizzes, we preprocessed guess value as $-\log(\text{guess} + \delta)$ for a problem with a lower guess value to be constrained by time to be optimized (note: We set $\delta = 0.001$ to avoid an error with a true log of 0 when guess = 0). For slip value, we input the raw slip value to optimize the more careless and error-prone quizzes that are constrained by time.

3.5 Optimization from individual student logs

For the convenience of students, we also introduced a method of optimization that constrains the percentage of correct answers and time for each individual student. One student's learning log was used based on whether he or she solved quizzes or not. We prepared two types of optimization. First, time constraints on his or her solved quizzes with low percentage of correct answers from his or her own learning log. Second, time constraints on his or her unsolved problems with high percentage of correct answers from other students' logs. The former type is expected to be used to effectively review areas of his or her poor performance before an exam, while the latter is expected to be used by students who have not studied much to gain confidence by solving easy problems before an exam.

4. Implementation of prototype into the learning system

4.1 User Interface screenshot

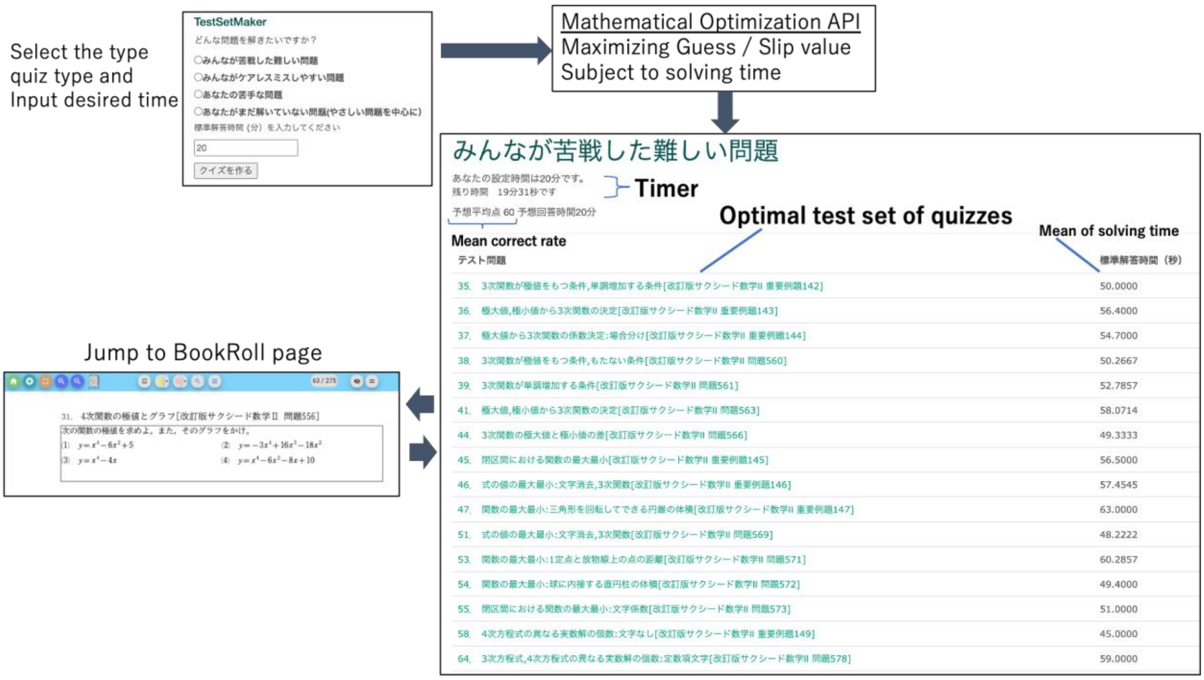

Figure 1. We implemented this mathematical Optimization API to the recommender system which we developed on LEAF framework

We implemented this mathematical Optimization API to the recommender system on the LEAF framework. The student selects the type of quiz to be optimized (BKT parameters or individual correct rate) and enters the time to be constrained, and this information is sent to the optimization API. The API performs the optimization process by constraining guess, slip, or the percentage of correct answers with the solution time, and outputs an optimal test set of quizzes that are optimal for the input time. As shown in Figure 1, optimized outputs test set of quizzes displayed on the page. At the top of the list of quizzes, a countdown timer and mean correct rate of quiz set are displayed. The right column of the optimal test set of quizzes, means of solving time are displayed. If a student clicks the title of the quiz, he or she can jump to the BookRoll page. After solving the quiz on the BookRoll page the student is supposed to return the optimal set of quizzes list page. When the timer reaches 0, a "Time up!" pop-up appears.

5. Conclusion and Future Work

In this study, inspired by a teachers’ practical example using an e-learning dashboard for creating exam questions, we proposed an automated test set quiz maker optimizing BKT model parameters and solving time. Future study needed to evaluate whether reducing the burden of creating exams on teachers and the effectiveness on students using this function as a trial test before exam.

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Performance Prediction of Learning Programming - Machine Learning Approach

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Abstract: Teaching and learning programming is a challenge faced by many educational institutions. In this paper we described using machine learning with data mining techniques to predict the performance of students using SMAC-based (social, mobile, analytics and cloud) programming learning tool (SPLT) that we developed for students to learn computer programming. Being able to predict and know students' performance has many advantages from educators', students' and administrators' perspectives for better learning, teaching, pedagogy design and institutional management. With the designed SPLT, experiments were conducted with 71 students from higher institutions who are learning computing programming. Various data were collected during the course of the experiment such as participants' demographics, programming background, logged data in SPLT, chat logs, pre- and post-tests scores for data mining attributes. Four classification algorithms were used to develop the classification model for the two datasets we prepared. WEKA was used to clean raw data, train and measure the performance of the models. Our experiment indicated that we were able to predict students' performance consistently with high accuracy of F-score using Random Forest classifier.

Keywords: analytics, machine learning, data mining, WEKA, social,

1. Introduction

Most modern learning institutions are highly competitive and operate in a complex environment. Therefore, there is a need to provide high-quality education and formulating strategies for evaluating the students' performance in order to identify future needs and the challenges faced by most learning institutions today. To implement student intervention plans is one of the best practices to overcome students' problems during their studies, at entry-level, and subsequent periods. Especially the management and educators will also benefit most in the planning, managing and designing course curriculum as needed to improve students' learning outcomes.

Learning computer programming has long been regarded as a challenge, particularly among computer science students, including those enrolled in the introductory programming course (Derus & Ali, 2014). Although several studies have documented the evidence of students' struggle in learning computer programming (Yang, Yang, & Hwang, 2014), there is no consensus on the main problem that students confront when taking this course (McCall & Kölling, 2014). However, one common issue that introductory programming students confront is their inability to think algorithmically due to a lack of problem-solving skills (Chung, Chou, Hsu, & Li, 2016) (Intisar & Watanobe, 2018). On the other hand, there is a rising trend in the adoption of machine learning techniques in programming education due to its tremendous potential, especially in predicting students' performance and understanding students' behaviour in programming education.

In this study SMAC (Social, Mobile, Analytics, and Cloud)-based programming learning tool (SPLT) (Rahim, Omar, Au, & Mashud, 2022) was used as an online learning system with an architecture that adopted the SMAC concept in the programming learning environment for helping to mitigate the issues faced by learning computer programming. To further enhance the SPLT, machine learning using data mining techniques were employed using students' background data and also data collected through the SPLT to predict the performance of the students. Several models of the machine learning were tested with 2 slightly varied datasets to examine the best model.

In the next section of the paper, background of machines leaning in education would be briefly discussed. Section 3 discussed the main components of SPLT. Section 4 described the experiment followed by section 5 which presented the results of the experiment. Section 6 concluded the paper.

2. Machines learning in Educations

Learning has evolved into many sizes and shapes including e- and blended-learning platforms such as LMS, MOOC and other types of digital environment. While this has provided a more flexible environment it also introduces challenges as traditional direct face-to-face learning interaction has reduced tremendously and some even to zero. Challenges such as loss of motivation, high dropout rates and ineffective learning outcomes are very common nowadays. This is especially so in learning programming in a computer course. In such case predicting students. performance at risk using machine learning would be useful.

In (He, Bailey, Rubinstein, & Zhang, 2015), Sequentially Smoothed Logistic Regression (LR-SEQ) and Simultaneously Smoothed Logistic Regression (LR-SIM) were proposed. DisOpt 1 and DisOpt2 datasets were used to evaluate the two algorithms. Comparing the results with the baseline Logistic Regression (LR) algorithm, LR-SIM outperformed the LR- SEQ in termsof AUC when compared to the results with Logistic Regression (LR), where the LR-SIM had a high ACU value in the first week. This could be very useful for early intervention during the entry stage of higher institution.

In (Kasem, Shahrin, & Wan, 2018), the authors predicted students' performance undergraduates' performance at an early stage of their study program and identified modules that could serve as strong indicators of performance at the end of the degree program in a university running computing course. Data was collected on students' academic performance throughout the four years of their study as well as related demographic and background information. Several classification techniques and sampling methods, were experimented with to over data imbalance. The studies achieved reasonable accuracy in predicting three graduation classifications adopted in the university by using Naïve Bayes method with Feature Selection technique based on Gain Ratio attribute evaluator. The study also indicated that modules in semesters 2 to 4 are more prominent than modules of first semester in serving as strong predictors.

In (Kotsiantis, Patriarcheas, & Xenos, 2010) the authors proposed combinational incremental ensemble of classifiers to predict students' performance. In the studies, three classifiers were combined to calculates the prediction output. In the end a voting methodology is used to select the final prediction. The technique was found to be useful for continuously generated data. When a new sample arrived each classifier predicted the outcome. A voting system was used to select the final prediction. In the studies the dataset consisted of assignments marks with 1347 instances each having four attributes with four features. Three algorithms used for building the system were I Bayes (NB), Neural Network (NN), and WINDOW. When a new instance of observation arrives, all three classifiers predict the value, and the ones with high accuracy are automatically selected.

In (Osmanbegovic & Suljic, 2012) they used I Bayes (NB), Decision Tree (DT), and Multi layer perception (MLP) algorithms to predict students' success. The first part of data is collected from the survey conducted at the University of Tuzlain 2010–2011 which consisted of the first year economics students. Meanwhile the second part of the data were collected from students' enrollment database. Overall the dataset has 257 instances with 12 attributes. In the studies, it was found that NB scored a high accuracy score of 76.65% with a training time of less than1 second.

In (Lakkaraju et al., 2015), a machine learning framework was proposed to predict and identify at risk students who were likely to fail and not graduating on time. This studies collected students data from two schools in two districts. The machine learning algorithms purposed consisted of Support

Vector Machine (SVM), Random Forest, Logistic Regression, Adaboost, and Decision Tree. These algorithms are evaluated using precision, recall, accuracy, and AUC for binary classification. Every student was ranked according to the risk score estimated from the classification based on the proposed models. This studies found that Random Forest performed the best.

6. SPLT

In this study we used SPLT (Rahim et al., 2022) as the learning platform for students' learning and to collect data for our purpose. There are two main requirements for SPLT: first, the system must be a cloud-based, mobile, and synchronous collaborative learning platform for programming education. Second, the system must generate and record relevant data necessary for educational data mining, mainly predicting students' performance and identifying at-risk students. Based on these two requirements, this study first analysed all widely experimented and proven effective programming learning tools identified from the SLR conducted by (Rahim, Omar, Au, & Mashud, 2021). The features of these identified learning tools were analysed to examine their effectiveness in enhancing students' problem-solving and collaborative skills. Analysing these learning tools helped this study identified the features that could adopt the SMAC elements into the system architecture. Figure 1 shows the identified features and the SMAC element they represent. The features were proposed to support a collaborative and synchronous programming environment that allowed distant students to collaborate seamlessly over a cloud-based system.

Based on the features in Figure 1, the architecture holds four primary functional units that worked in tandem to provide these features. In general, the synergy of these four functional units aided students in developing their collaborative skills and problem-solving ability through continuous collaboration in problem-solving oriented programming exercises. As illustrated in Figure 1, the four functional units are the *Synchronous Collaborative Unit* (SCU), *Exercise Analysis Unit* (EAU), *Portfolio Unit* (PU), and *Visualisation Unit* (VU). These units will be discussed throughout the chapter.

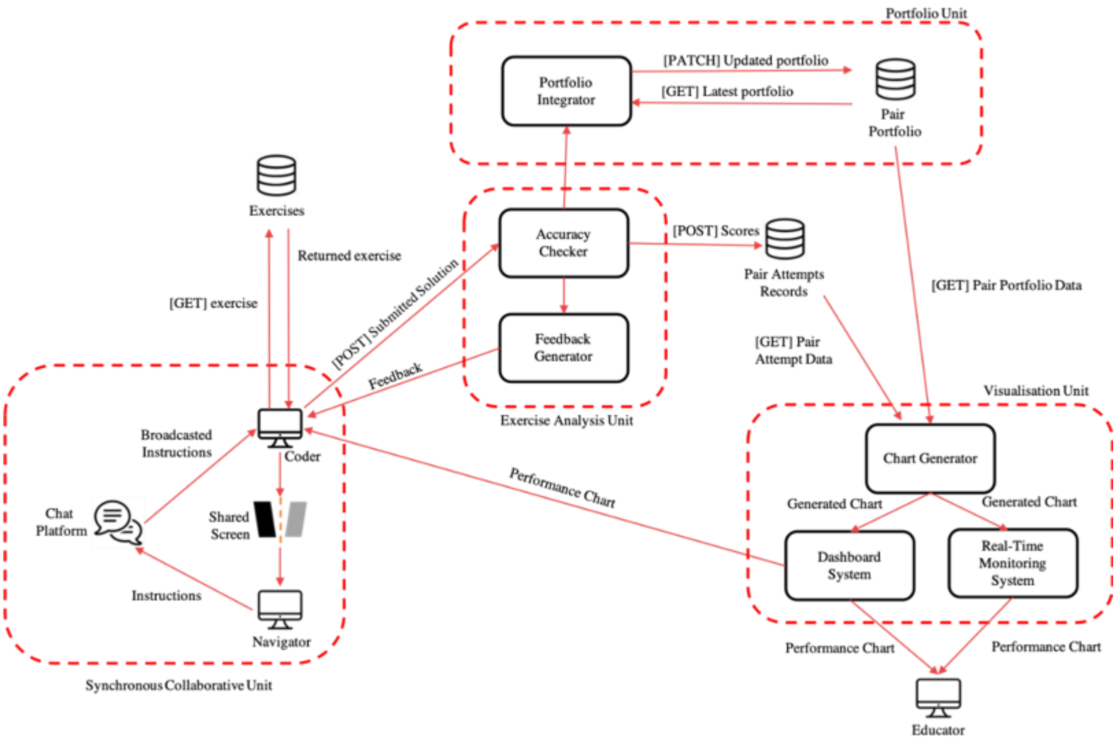

Figure 1. The system architecture for a SMAC-based Programming Learning Tool (SPLT) (Rahim et al., 2022)

7. *Synchronous Collaborative Unit (SCU)*

Referring to Figure 1, Synchronous Collaborative Unit (SCU) is a functional unit that specifies how combining three SMAC elements (social, mobile, and cloud elements) can establish a cloud-based (online) and mobile programming learning environment with synchronous collaboration capabilities. This unit resides at the architecture frontend to hold all the user interfaces for students to interact with the system. Overall, it included all student-oriented features that enabled students to exchange information (Khan, 2020), developed their problem-solving skills for programming and collaborate with other students in programming activities through an online environment.

This functional unit first examined the social element's incorporation into the architecture. Existing studies indicated frequent use of these two collaborative formats in programming education: 1) pair programming and 2) group programming. The goal of this unit was to establish an online and cloud-based learning environment.

3.2 Synchronous Collaborative Unit (SCU)

The SCU functional unit incorporated the cloud and analytic elements into the learning tool by holding two main components: *Accuracy Checker (AC)* and *Feedback Generator (FG)*. Residing at the business logic layer of the architecture, this unit and its two components aimed to perform the analytical tasks in the system by analysing students' performance and behaviour based on their activities in SPLT. All analytical processes in this architecture were done on the cloud to establish a proper cloud-based system. In general, this unit analysed the data generated by students, such as their solution accuracy, solving time, number of movements, and number of attempts. This functional unit helped to strengthen the grounding of all analytical processes by two outcome measurements suggested by (Ko, LaToza, & Burnett, 2015), namely *"success on task"* and *"time on task"*.

8. *Visualisation Unit (VU)*

This functional unit incorporates cloud and analytics elements with the goal to 99ategoriz the output generated by all analytical processes carried out in the Portfolio Unit (PU) and Exercise Analysis Unit (EAU). As illustrated in Figure 1, this unit has three main components: (1) *Chart Generator*, (2) *Dashboard System* and (3) *Real-Time Monitoring System*. These components resided both at the architecture's front- and back-end and 99ategori the data they received from the other functional units to generate learning progression charts.

9. *Portfolio Unit (PU)*

This functional unit also incorporated the cloud and analytic elements into the architecture, but it was responsible for establishing a portfolio system (PS) that classified students based on their performance over time. For this purpose, all data generated by the students in the system could be used to create a PS. The PS would provide insights into their learning progression, allowing educators to identify at-risk students quickly and effectively for responsive assistance. Studies have shown the importance of providing necessary assistance as quickly as possible (Azcona & Smeaton, 2017; Nakayama, Ishiwada, Morimoto, Nakamura, & Miyadera, 2018)

This functional unit had two core components: the *Portfolio Integrator* and the *Pair Portfolio Database.* The Portfolio Integrator must include all the functionalities required to establish the PS. First, it must extract the Exercise Analysis Unit data, specifically new students' activity data (such as scores and solving time). Then the Portfolio Integrator would get the latest portfolio of the student from the Pair Portfolio Database and update the students' portfolio accordingly based on this new data. To this end, the Port Portfolio Database is only responsible for storing, updating, creating, and deleting students' portfolio data.

10. Experiment

The population of this study involved students enrolling in the introductory programming modules. In the context of Brunei Darussalam, different institutions named the introductory programming module differently, such as *Fundamental of Programming*, *Introduction to Programming*, and *Programming 1*. This module is usually offered as a core module in the first or second semester of the first academic year, and all computing students must enroll in this module. This study applied the convenience sampling method to recruit participants from various public and private higher institutions offering introductory programming modules in Brunei Darussalam. Participation in this experiment was voluntary. An online registration form through Google Form was created and opened for one week to allow students to register at their own will. Additionally, the participants were allowed to withdraw without providing any valid reason. Table 1 showed the number of participants participating, participants completing the experiment, the levels and the institutions.

Data collection and analysis methods were essential components of this study because they provided the data necessary for understanding the effectiveness of SPLT in enhancing the problem-solving and collaborative skills of the programming students. Accordingly, the data collected in this study originated from three primary sources: (1) logs from the SPLT proof-of-concept system, (2) questionnaires, and (3) pre-and post-study test scores.

The pre-and post-study tests were administered before and after the experiment. The pre-test aimed to measure the participants' prior problem-solving ability, meanwhile the post-test measured any changes in their problem-solving ability after using the SPLT. Both tests had similar structures, which involved five questions that all participants must solve within allocated time. The five questions covered programming topics on code tracing, code debugging, iterations, conditions, and arrays. In ensuring the validity and reliability of the test questions and their marking rubrics, a senior programming lecturer from the Universiti was appointed to validate them.

Table 1. *Total number of recruited participants and who completed the experiment*

Institution	Educational level	No. of participants participating in the experiment	No. of participants completing the experiment
IBTE	National Diploma	4	4
Politeknik Brunei	Diploma Level 4 and Level 5	23	10
Universiti Teknologi Brunei	Bachelor's Degree	37	32
Universiti Brunei Darussalam	Bachelor's Degree	3	3
Micronet International College	Diploma Level 4 and Level 5	17	8
Kolej IGS	Diploma Level 5 and Bachelor's Degree	14	14

Table 2. *Attributes for dataset 1and dataset 2*

Dataset	Attributes
1	• Demographics: age and gender • Programming background: years, modules enrolled, and the project involved • SPLT log: up move, down move, total move, input score, process score, output score, total scores, and solving time • Class: Normalised learning gain
2	• Demographics: age and gender. • Programming background: years, modules enrolled, and the project involved • SPLT log: total move, total scores, and solving time • Class: Normalised learning gain

Data collected included students' demographics (age and gender), programming background (programming years, programming modules enrolled, and programming project involved), chat logs, and pre and post-study tests scores. These data can be used to develop the datasets required to train the predictive model that predicts or classifies students' performance based on their behaviour while using SPLT and identified weak-performing students as early as possible after using SPLT.

This study proposed classifying the students into at least three primary classes: low performing, average performing, and high performing. This grading strategy could also be used as the class attribute. The pre-and post-study test scores after using SPLT were used to calculate each student's 101ategoriza learning gain (NLG). Then, the grading strategy was used to label the class for each instance in the dataset based on its NLG value. Hence, the class attribute in the datasets of this study depended on the NLG of each student.

Two datasets were developed based on the collected data above mentioned. Table 2 showed the attributes of each dataset. In brief, the first dataset included students' demographics (age and gender), programming background (programming years, programming modules enrolled, and programming project involved), SPLT logs (up move, down move, total move, input score, process score, output score, total scores, and solving time), and the NLG class. This dataset examined whether finer data details would better classify students' performance after using the system.

Meanwhile, the second dataset had fewer attributes because it aggregated some related SPLT logs. In short, the SPLT logs included in Dataset 2 comprised the total move, total scores, and solving times. The rationale of this dataset was to examine whether aggregated details (lesser number of attributes) are better than segregated details (more attributes, as seen in Dataset 1) in classifying the students' performance.

All data mining processes, from data cleaning to model performance evaluation in this study, were done entirely by using WEKA Explorer (Bouckaert et al., 2008). The data cleaning conducted included identifying and handling outliers and missing values.

There were various supervised data mining algorithms to make the classifications. Classification was a supervised technique that 101ategorizat an instance based on the class attribute. This study adopted four classification algorithms to develop the classification model. These algorithms were adopted due to their wide application in the literature relating to educational data mining (Hämäläinen & Vinni, 2010; Poonguzhali, Sujatha, Sripriya, Deepa, & Mahalakshmi, 2021): *Naïve Bayes: C4.5 Decision Tree: K-Nearest Neighbour:Random Forest:*

In evaluating the model performance we adopted the three most commonly used tools to measure the performance of a classification model included confusion matrix, learning curves, and receiver operating curves (ROC) (Oprea & Ti, 2014).

This study experimented with filter (InfoGain and GainRatio) and wrapper approaches to explore and compare their performance with the original and discretised dataset. The performance for each model was evaluated and compared to identify the best performing model based on its F-Score value. Also, all models were tested by using the ten-fold cross-validation technique.

11. Results and Discussion

Results were tabulated in Table 3. The results indicated that Dataset 1 performed the best with the Random Forest classifier (F-Score = 0.957), especially when its continuous attributes were discretised and its irrelevant features were removed by using the GainRatio method. Meanwhile, Dataset 1 performed the poorest when using the KNN classifier (F-Score = 0.515) without applying 101ategorization and feature selections. In identifying the attributes that significantly contributed to the classifications, we further observed that the four leading indicators to classify students' performance are *age, prog_modules*, *prog_project,* and *scores*. And students' age, programming background and overall scores in SPLT could help classify their performance. Table 4 showed the confusion matrix of the best performing model for Dataset 1. The confusion matrix informs that the model can accurately classify 246 of the 254 instances, which translates to 95.6 per cent accuracy

Meanwhile, Dataset 2 contained fewer attributes but still hold the characteristics that could examine whether the data collected from SPLT, demographic, and programming background could be used to classify students' performance. The results showed that the KNN classifier did not perform well with Dataset 2. After applying the features reduction and 101ategorization, its performance only peaked at F-Score = 0.658. However, the results showed that Dataset 2 performed the best when using the Random Forest classifier and its attributes were discretised (F-Score = 0.949). Table 4 showed the confusion matrix for the best performing model on Dataset 2. The confusion matrix informed that the model can accurately classify 246 of the 254 instances, which translates to 93.7 per cent accuracy.

Comparing all classifiers' accuracy (F-Score) on Dataset 1 and 2, the best performing model was Dataset 1 with Random Forest classifier, which involved applying 102ategorization and the GainRatio method on its attributes (F-Score = 0.957). Meanwhile, the poorest performing model used the KNN classifier on Dataset 1 without 102ategorizati (F-Score = 0.515). Most importantly, the outperforming result of Dataset 1 using Random Forest classifier suggests that having finer attributes and reducing them by using feature selections might results in better prediction model performance. This finding aligned with (Beniwal & Arora, 2012; Cahyani & Muslim, 2020; Doshi, 2014) on the usefulness of feature reduction that removed irrelevant and redundant attributes from the model. We postulated that having more relevant data about students' behaviour would help in predicting their performance better. Future educators who wish to improve the model may try adding more relevant attributes into the existing model. However, we recommended performing feature selections especially when some algorithms may not perform well with many attributes (Beniwal & Arora, 2012).

Furthermore, the results also demonstrated that the C4.5 Decision Tree classifier's performance peaked at F-Score = 0.924. In choosing the best model with the C4.5 Decision Tree classifier, this study examined the decision trees produced by each model and explored the classifier with the smallest decision tree (Table 4). The rationale is that fewer leaves will make it easier to interpret the decision tree which is in line with (Fayyad, Irani, & Arbor, 1990) that fewer leaves would reduce the classifier's error rate and increase its performance. Table 4 compares the sizes of the decision trees produced by the classifiers. Model no. 1 had the smallest tree produced (tree size = 57). However, the model had the lowest F-Score (0.886) compared to all other models. Hence, this study considers both F-Score and tree size to determine the best classification model with the C4.5 Decision Tree. The fourth model (model no. 4) satisfied these two factors from the results. the model had a tree size of 93 (105 leaves) and an F-Score of 0.924. Therefore, by considering the assertion of Fayyad et al. (1990), this study concluded that the decision tree produced by the fourth model could be used to identify the attributes that contributed to the classification of the students' performance

Table 3. *Comparisons of classifiers' accuracies (F-Score) on Dataset 1 and 2*

Experiment	Classifier	Dataset 1	Dataset 2
Original	NB	0.596	0.624
	C4.5	0.886	0.886
	RF	0.863	0.898
	KNN	0.515	0.652
Discretisation	NB	0.698	0.707
	C4.5	0.905	0.924
	RF	0.905	0.949
	KNN	0.646	0.614
Discretisation + Wrapper	NB	0.765	0.757
	C4.5	0.924	0.917
	RF	0.941	0.937
	KNN	0.666	0.658
Discretisation + GainRatio	NB	0.729	0.718
	C4.5	0.913	0.924
	RF	0.957	0.933
	KNN	0.669	0.567
Discretisation + InfoGain	NB	0.687	0.711
	C4.5	0.920	0.924

RF	0.921	0.925
KNN	0.649	0.607

Key:
NB – Naïve Bayes, C4.5 – C4.5 Decision Tree, RF – Random Forest, KNN – K-Nearest Neighbour

Table 4. *Sizes of Decision Trees Produced by Different Classifiers*

Experiment	Model No.	Data set	F score	No of leaves	Tree size
Original	1	1	0.866	29	57
	2	2	0.866	30	59
Discretisation	3	1	0.906	120 93	135
	4	2	0.924		105
Discretisation + Wrapper	5	1	0.924	112	125
	6	2	0.917	102	115
Discretisation + GainRatio	7	1	0.913	110	123
	8	2	0.924	100	111
Discretisation + InfoGain	9	1	0.920	100	111
	10	2	0.924	100	111

Table 5. *Confusion Matrix of best performing classifier on Dataset 1 and Dataset 2*

Dataset 1		*Predicted Class*		
		HL	HM	HH
Actual Class	HL	68	0	2
	HM	0	87	5
	HH	3	1	88
Dataset2				
Actual Class	HL	65	2	3
	HM	0	88	4
	HH	4	3	85

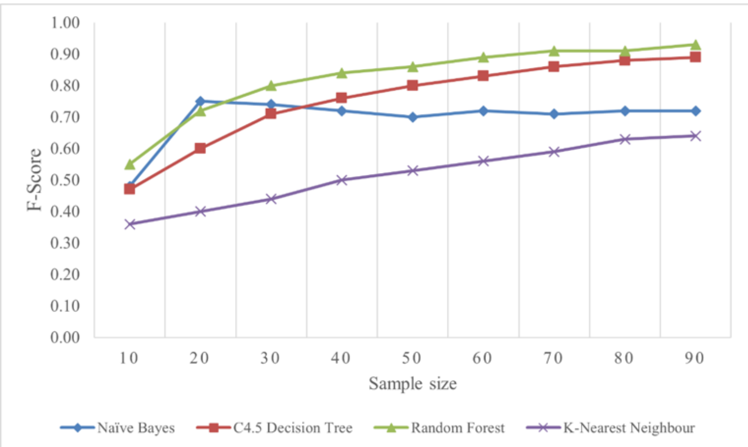

Figure 2. Learning curve of best-performing classifiers for Dataset 1

Figure 2 and 3 showed the learning curves and the performance of all classifiers improved with the increasing percentage of the sample size used in the training dataset. This finding indicated the accuracy of the current size used in training the classifiers, suggesting that adding more data to the training dataset will improve its accuracy. However, as indicated in Figure 2 and 3, further adding more data into the training dataset will not provide any significant benefit. Therefore the learning curve could be used to determine the point in which adding more data will not help improving the performance further and also to 104ategori the training time ensuring that the model will not suffer from overfitting (Mohr & van Rijn, 2022).

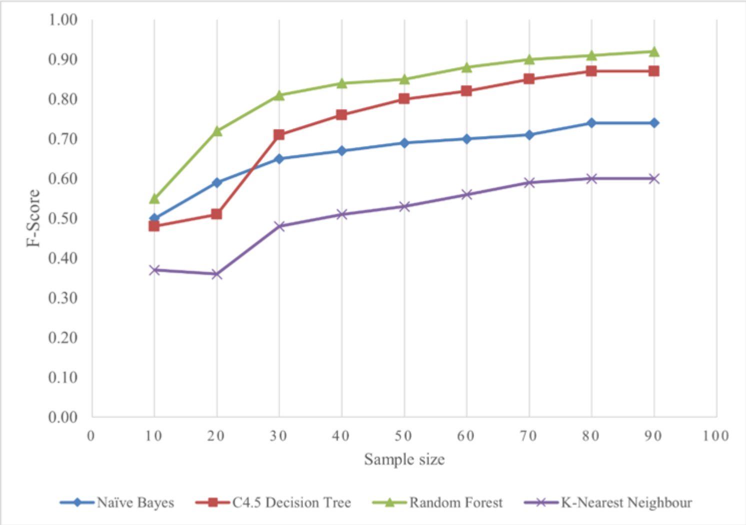

Figure 3. Learning curve of best-performing classifiers for Dataset 2

12. Conclusion

In this study we were able to prepare and develop two datasets from students' pre- and post-tests scores, demographics, programming background, and SPLT logs in order to develop the predicting machine learning models. The models were evaluated by different performance metrics, including the accuracy, true positive rate (sensitivity), F-Score. In particular the study 104ategor more on evaluating their F-Score due to its wide application in the literature. Four classifiers (algorithms) were used to train the model: Naïve Bayes, C4.5 Decision Tree, Random Forest, and K-Nearest Neighbour. In further enhancing the performance of the models, this study adjusted the parameters, including applying 104ategorization, 104ategorizatio, and feature selections (Wrapper, InfoGain, and GainRatio). Also, this study tested all models by using the ten-fold cross-validation technique. The evaluation results showed that Random Forest Classifier model was the best performing model in this study. In Dataset 1 the model performed the best when using the Random Forest classifier with 104ategorization and the GainRatio method. On the other hand, Dataset 2 performed the best when using Random Forest classifier with 104ategorization and Wrapper method. The learning curves for both datasets also demonstrated that adding more data into the training dataset will not increase the performance significantly as the models reached their plateau. The results from this study demonstrated the ability of using demographic data and behaviour data to predict at-risk students in early phase of the course and automate the process of grading students' performance. In the future, we recommend researchers to extend this study by examining the ability of using the two data to predict students' performance at different intervals during the duration of the course. This study believes that it would help educators to clearly identify any possible problems with the course structure and perform any necessary interventions to mitigate the identified problems.

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A Framework for Behavior Analysis of an Essay Writing for Understanding Learners' Thinking Process

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Abstract: In this paper, we propose a writing supporting tool to train users' cognitive skill and to monitor their action in the tool for behavior analysis. The tool is to ask users to declare their thought and logical relation of sentences in their writing. This helps users to start thinking about their thought by focusing more on idea and strategy. By detecting users' action to the tool user interface, we can study and analyze users' behavior during the writing process that reflects their thought perspective including content understanding and planning. From an experiment, we found that users who obtained high rating from written essay have common solid action patterns as providing content, selecting the type, and assigning relationship respectively, and they generally spend less time in every action. On the other hand, users who produce an essay with low rating share fewer common patterns, and the patterns are sporadic while they need to redo the actions several times. The results also suggest that the thinking about an intention of a content and relationship of sentences gives the better essay rating than not.

Keywords: Behavior analysis, writing monitoring, cognitive training tool, metacognition

1. Introduction

As writing is a way of communication in terms of conveying own thinking to the receiver with explicit media for a solid proof (Keith Oatley, 2008), it can be used to analyze and criticize for a writer to improve their skill. Writing involves several cognitive aspects including creativity, critical thinking, strategic thinking, and memorizing (Bean, J. C., & Melzer, D., 2021). Several studies have proposed to train a writing skill for cognitive development (Kellogg, R. T., 2008). The result of those studies indicate that writing is a good method to train cognitive skills including creativity, sharpening memory, planning, and sorting out understanding. The writing has two major components which are content or idea and strategy. The content part is the transfer of knowledge or ideas through the analytical process of the writer communicating to the receiver. The strategy aspect is to plan on how to transmit the ideas so that the content is highly connected, trustworthy, and convincible (Brown, 1987) (Wong, 2005). A written output such as an essay is a traceable evident that reflects writer's thinking via words, style, and logical connection within and of sentences (Stallard, 1974). Therefore, detecting learner behavior in activities of writing an essay can help identify thought processes and planning.

In the past, we developed a tool to train learners' cognitive skill via a writing supporting tool (W. Na Chai, 2017) (W. Na Chai, 2019). By asking a learner to provide content and its related information in a sentence level, learners should halt their running thought and focus more on idea and strategy for writing as well as thinking about their own thought. The training is to understand one own thought and control cognitive performance as metacognitive skill (Mahdavi, 2014). Thus, metacognition is one of the higher-order thinking skills that can be used to clarify students' thinking or planning processes in activities such as writing (Stewart, 2015).

To improve the tool further, we aim to monitor activities that learners conduct during their training in the tool. We aim to study and analyze behavior regarding activities of writing an essay based on the tool for cognitive training. The finding from analysis can reveal the relation between learners' thinking process and their behavior. This can help instructors to understand learners more clearly and design a training method for personalized learning. Moreover, by comparing the rating results of essays and behavior, we can learn the suitable actions to improve the tool further.

2. Framework for Behavior Analysis of an Essay Writing

This section is to describe a framework that we use as a tool to analyze learner's behavior towards thinking process. The framework is initially a tool to assist learners to focus on thinking process while writing an essay by asking users to declare their thoughts via annotation method. The tool thus helps users to realize their thought and gives them a chance to train their metacognitive skill. To enhance the tool further, we apply a method to monitor users' activity on the framework. From observation of the users, we found that users tackled the tasks given from the tool differently and their activity may corelate to the training results. Thus, in this work, we attempt to monitor and record users' actions for analyzing how their behavior may relate on how they think and their thinking process. Functions of the tool remains the same for users to write an essay while users' task is to provide the following.

- Writing content in a sentence level
- Selecting a type of a content from a predefined list of content type
- Assigning a relation of the current sentence to the previous sentences based on selected content type

The aforementioned tasks are conducted via the framework. In this work, we develop and add a monitoring function to detect typing and mouse-clicking on the user interface of the tool and to record them as a log for analysis. An overview of the upgraded framework is given in Figure 1.

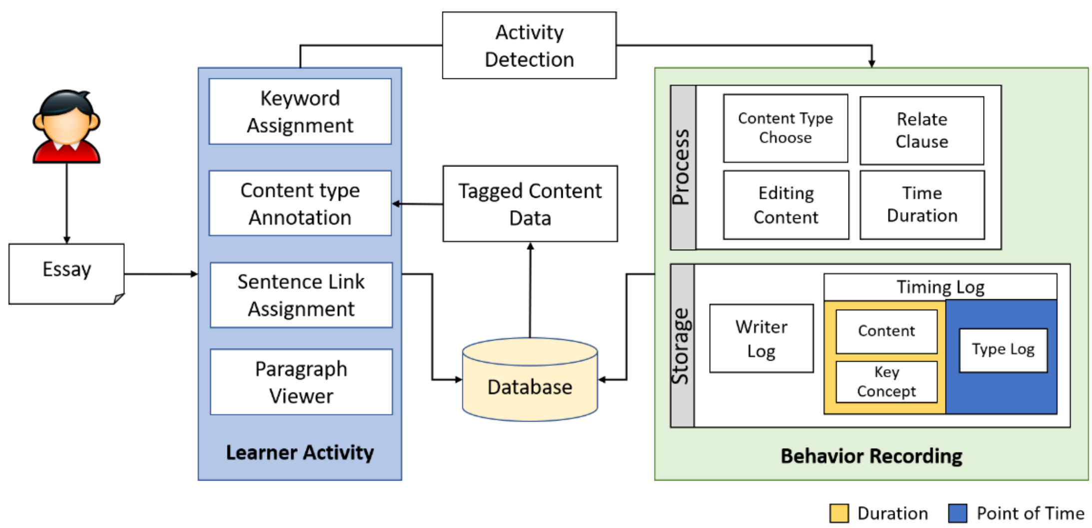

Figure 1. An overview of the upgraded framework of training thinking process via writing and behavior analysis

2.1 Tool Activities

By keeping the objective to train users on thinking process in writing an essay, the tool is designed to provide a web-based user interface for users to provide the writing content and information related to the content. In the tool, a user is asked to split up their thought and input the content for single sentence in each row. The mandatory required information related to the content in the tool includes 'what intention the content is for', and 'which other sentence is related to the intention'. The former is called 'content type' and we provide a list of types for user to select in a form of a dropdown list in the user interface. The latter is for a user to assign a sentence ID if the working sentence is linked to the previous sentence regarding the selected content type. A user interface of the tool for a learner to provide the content and related information is illustrated in Figure 2.

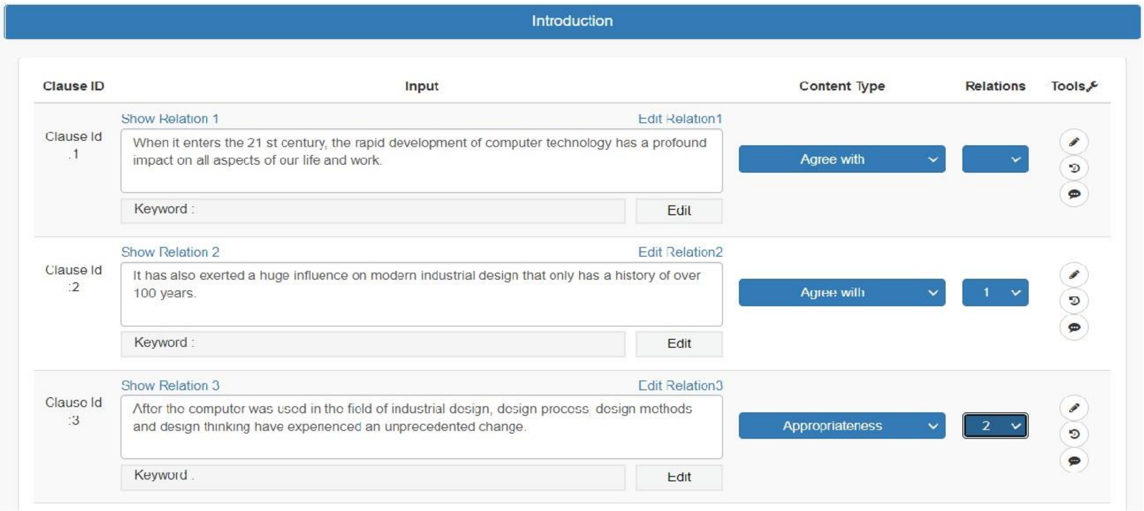

Figure 2. An example of tool user interface for a learner

The user interface is designed following the concept of a thinking sequence. From left to right, a user is asked to provide content, to select a content type, and to assign sentence ID for linking sentence, respectively. The design is based on the idea that a user should think about what to mention, what kind of content, and the thinking is related to another or not in a sequence. We expect that thinking in such a manner will improve systematic thinking and may allow a user to increase a chance to think about their thoughts more thoroughly as well as their strategic thinking on convincing the reader.

2.2 Behavior Data Collection

For the task of behavior analysis, we develop a monitoring system to record users' action towards the tool. Initially, the tool was designed to collect the content and related information provided by a user. In this work, actions regarding the given tasks mentioned in the previous sections is recorded. We expect that recorded actions can be used in analysis to help us to understand users for personalized learning and improve their training results. Furthermore, we may find a thinking process of the users by grouping the behavior of the users. In this section, we explain the monitoring method and a generated action log.

We design the tool to record every action throughout the process of essay writing that a user conduct on the tool. There are two main data for the tool to detect and record including the action to the task and timing of the action. The tasks are 1) typing a content (T), 2) select a content type (C), and 3) to assign related sentence ID (R). The timestamp of an action for both starting time and ending time. With the record of action and time, we can realize action order and how long a user spend time in an action. The details of detection and record is summarized in Table 1.

Table 1. *Generated Data from Detecting User's Actions via the tool*

Detection type	Interacting with Input type	Recoding information	Description
Timestamp	Typing in Writing panel	• Starting time • Ending time	Calculation for a duration of writing content
	Clicking Dropdown of content type	• • Starting time Ending time	Calculation for a duration of selecting a content type from the list
	Selecting the content type	• Starting time • Ending time	
	Clicking Dropdown of relational sentence	• Starting time Ending time	Recording time to relation between sentence

		•	
Order of Action	Writing panel, Dropdown of content type and Dropdown of relational sentence	• Order of action	Recording an order of actions based on time and duration

Since the action can be redone freely in a row panel, we generate a log of conducted actions of each sentence row until a user move to another sentence row panel. Users also allow to rework on the finished sentence row after working on another sentence, but the rework is recorded and regarded as a separate record to prevent complex data management. After a user submits the writing as finished, a log is generated for a learner user to review their endeavor. In a log, not only recorded actions are provided but also the input contents and related information are given. A log is also useful for instructors and training coach for analysis and providing guidance. An example of a log is given in demonstrated in Figure 3.

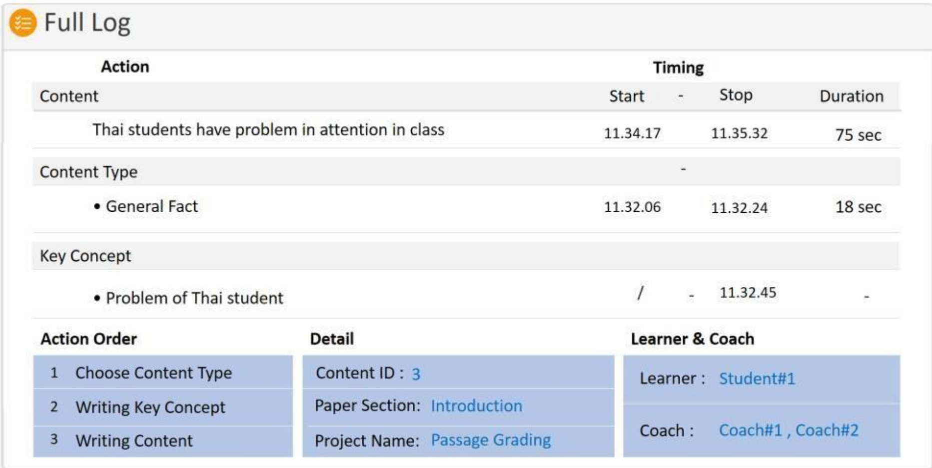

Figure 3. An example of an action and content log

3. Results

In this section, we aim to test the framework and analyze the behavior of users to examine their actions based on the framework specification. We asked 15 participants who are Thai native and at least studying in undergraduate degree in any major. The assigned task is for participants to write a short essay (about 10-20 sentences) within 3 hours using the framework. The topic of the essay is unlimited but is advised to be a topic that a user is excel with. The participants were trained on how to use the framework for 2 hours prior to the experiment period. The participants were informed that the framework has the action monitoring function, and they all gave a verbal consent for their actions towards the framework to be monitored and recorded.

For data collection, we collect their personal information including age, highest education level, and degree. The behaviors for analysis were recorded based on the given detail in Table 1. In terms of essay assessment, we assigned three coaches to give scores for the essays in three aspects including soundness of the content, accuracy of the selected content type, and accuracy of the given relation regarding content connectivity. The three aspects were to be rated for ‘0’ and ‘1’, where ‘0’ represents unacceptable, and ‘1’ is acceptable from overall. The ratings in each aspect from coaches were considered as voting, and the majority rating was chosen to represent the rating of an essay for that aspect. For sum of all three aspects, maximum score is 3 and the minimum is 0. We then split the participants into two groups based on the obtain summary score. Thus, the first group is those having over 1.5 sum score to represent the participants who have concise thinking process in writing, and the second group is for those having 1.5 sum score and below. As a result of grouping, the first group (G1)

contains five members, and the second group (G2) has 10 members. The groups were a base for comparison of their behavior in writing an essay via the framework. For statistics, there are 15 essays from 15 participants. There were 193 sentences and average sentences written per participant were
12.87 sentences, while minimum is 11 sentences, and maximum is 15 sentences per person. The language of an essay can be written in both Thai and English, but all participants chose to write in Thai by their free will.

As we collect the actions of writing an essay on the framework, their actions were recorded regarding action sequence, and timing of actions. Hence, we can create the patterns of the actions per sentence of each participant, and the duration spent for each action. From all participants, we found that there were 42 behavior patterns in total and frequency of each pattern as shown in Table 2.

Table 2. *Behavior patterns of participants in writing an essay based on the framework functions. (T = typing, C = selecting a content type, and R = selecting a relation of content)*

No.	Behavior Pattern	Frequency of G1	Frequency of G2	Summary
1	T | C | R	50	33	83
2	T | R | C	15	27	42
3	T | C | R | C	4	5	9
4	C | T | R	3	2	5
5	T | C | T | R	0	5	5
6	R | T | C	0	4	4
7	T | C | R | T	1	2	3
8	C | R | T	0	2	2
9	C | T | R | T | C | R	0	2	2
10	T | T | C | T | C | R	0	2	2
11	T | T | C | R | T	0	2	2
12	T | R | C | C	0	2	2
13	T | C | T | C | R	0	2	2
14	T | C | R | T | C	1	1	2
15	C | R | T | T	0	1	1
16	C | T | T | R	0	1	1
17	C | T | T | T | R	0	1	1
18	C | T | R | C | T	1	0	1
19	C | T | R | C | R	0	1	1
20	R | T | C | T | C	0	1	1
21	C | T | R | R	0	1	1
22	C | T | R | T | C	1	0	1
23	C | T | R | T | R	0	1	1
24	C | T | R | T	1	0	1
25	T | T | C | T | R	0	1	1
26	T | T | R | C	0	1	1
27	T | T | T | R | C | R	0	1	1
28	T | R | R | C | T	0	1	1
29	T | R | T | C	1	0	1
30	T | R | C | C | C	0	1	1
31	T | R | C | C	0	1	1

32	T | R | C | C | T	0	1	1
33	T | R | C | R	0	1	1
34	T | R | C | T | C | R	0	1	1
35	T | R | C | T	0	1	1
36	T | C | T | T | C	0	1	1
37	T | C | T	0	1	1
38	T | C | C	0	1	1
39	T | C | C | R	0	1	1
40	T | C | R | C | R | R	0	1	1
41	T | C | R | R	0	1	1
42	T | C | R | T | T	0	1	1

We also collect the data of duration of each action calculated from initial time and end time to show how much time they spent in each function. In a case of redo and edit of the same action of a sentence (such as do typing as first action and conducting a typing again as forth action as in the pattern#7 and #25), the times of all same actions are counted together to represent the duration. For typing action, we realize that typing speed may affect the statistic thus we use the average of a string count and time spent to represent the typing data of each individual instead of raw duration. With the average typing time per string of an individual, we can see which session students spend more or less time To represent the data, we calculate for mean duration (mean), minimum duration (min), maximum duration (max), and standard deviation (SD) of each framework function. The duration results based on grouping are given in Figure 4 and Figure 5.

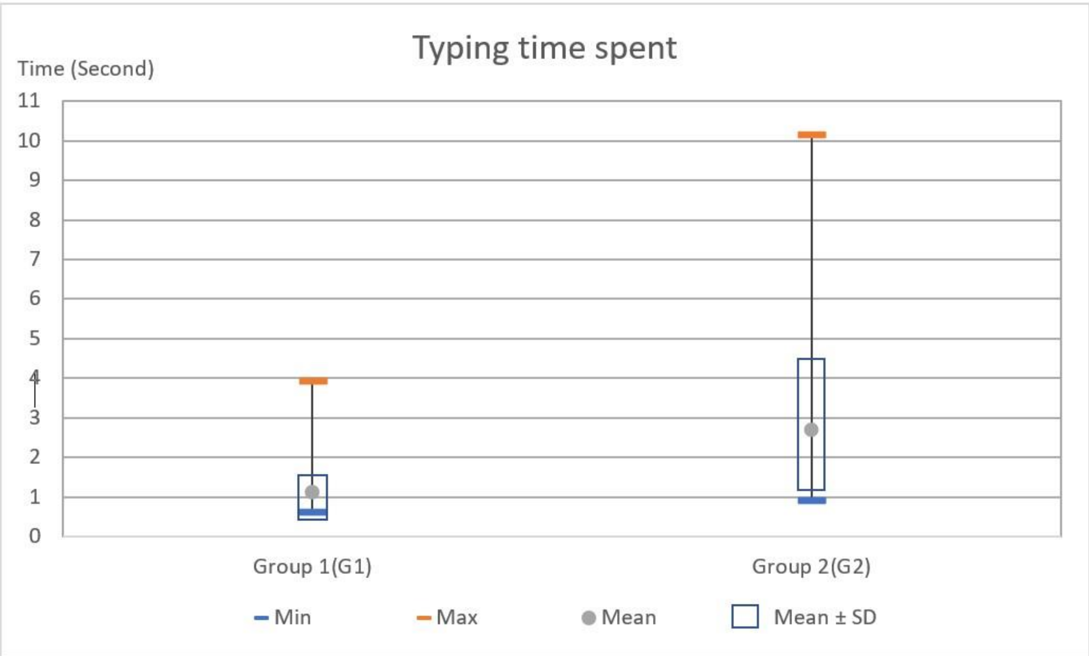

Figure 4. Comparison graph of typing time spent between G1 and G2

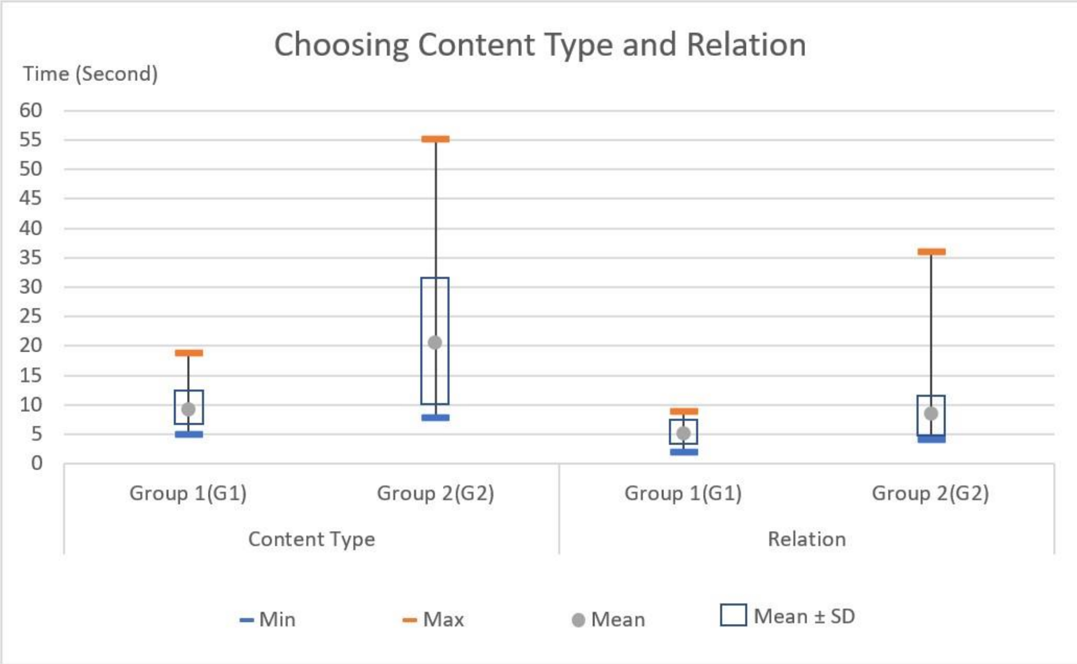

Figure 5. Comparison graph of choosing content type and relation between G1 and G2

4. Analysis and Discussion

From the results, we can see that participants had various patterns as 42 unique patterns from 193 sentences. The distribution of the patterns as shown in Table 2 indicates that the occurrence of patterns based on a group is different and some patterns were more frequent than the rest. The list of patterns from G1 consists of 10 unique patterns while the G2 compose of 38 unique patterns, there are 4 patterns common between the two groups. We also find that the patterns from G1 mostly contain 3 actions (88.46%) indicating that there are few edit/redo actions in their endeavor. This shows that participants in G1 may have more complete and clearer thoughts before performing the writing. Regarding time spent on actions, the result shows a noticeable difference between the two groups. The G1 group had less time consumption in all functions compared to the shared patterns. This also supports the conclusion of G1 participants to have more complete and clearer thoughts since they spent less time thinking in action but rather thinking clearly before doing.

Based on the analysis, we notice that there are 2 patterns that play a majority role as frequent over 20%. These patterns are common in both groups. Especially, pattern#1 and #2 took over 43.01% and 21.76% of all patterns, respectively. Since the pattern of a sequence of typing, selecting content type, and selecting a relation of content is resembling the user interface of function order from left to right following the UI design to let a user think in a significant order, it is common for participants to follow the order subconsciously without realizing. However, a comparison between the 2 groups shows the difference in frequency of the pattern#1 and #2 is 35.4% and 4.25% whereas G1 has 64.1% and 19.23% frequency of pattern#1 and #2 and G2 has 28.7% and 23.48% respectively. This shows that participants who obtained a high rating (G1) often use the pattern#1 more than low rating participants, and this pattern of writing behavior may differentiate the result of a written essay as they think systematically.

Once combining aspect of pattern and duration, we found that the overall average time spent in writing an essay of those in G1 were shorter. The time spent on actions can be analyzed as follows. The typing time spent refers to the time a user spending in providing the content. In this case, we used the average time per sting of each individual as a base to decide which sentence creation is short or long. We assume that the longer the time spent on typing, the more unclear the thought/idea user has. The time spent in selecting a content type represents a degree that a user understands his/her own content as to what role this sentence is for. Similarly, selecting a relation represents connectivity of thoughts from a user. For categorizing, this can be defined based on time spent and correctness (decided by coaches) into 6 types: fast and correct selection, fast and incorrect selection, normal and correct selection, normal and incorrect selection, slow and correct selection, and slow and incorrect selection. The preferred categories are those with correct rating whereas the shorter duration means how clear a user plans and think ahead, but the long duration is still admirable for thinking until the thoughts are clear and correct. However, the incorrect selection aspect is different since the faster they select may refer to not thinking about the content at all (as no plan and no strategy) or neglecting the importance of understanding own thoughts. For those in this category, they may need to be informed about the basis and importance of thinking as a groundwork towards cognitive skill training. The longer time spent but incorrect still is admirable as a user tries to spend time thinking but may not excel enough in cognitive skills to reach a correct answer, thus this group may need a lesson to improve the skills accordingly.

According to coach rating, coaches gave the impression that the essays of those from G1 were more thoughtful to readers and rationally connect throughout the content as they had a strategy to convince the readers more than those of G2. On the other hand, essays from G2 have the characteristic of a standalone sentence. Though the content in each sentence was fine, the connectivity of sentences was lacking and the assigned relations from the user were incorrect or the content of the linked sentences was not as specified. In terms of selecting the content type, the G1 specified the type correctly as they understood what they were aiming to mention, while the assigned content type from G2 often choose the common ones such as reasoning and consequence, but they were incorrect regarding the given content.

5. Conclusion and Future Work

This paper proposes to use the writing tool to include the function for monitoring actions towards behavior analysis. The actions that a user conducts are recorded and analyze for action patterns to represent how they think or strategize on convincing reader in an essay writing. The framework for an essay writing consists of tasks for a user to type the content, selecting the content type (a logical type of content), and selecting the relation to another sentence. The monitoring includes action sequence, and duration in each action.

In a summary, the results of behaviors based on the framework can differentiate the participants into two distinct types. The found patterns show the common actions of thinking process from those having decent thinking process. The findings of this study are that the writers who have clear and complete thinking process spend less time in writing, mostly act in a pattern of typing, selecting content type and selecting relation respectively, and rarely require redo/edit the typed contents. In the future, we plan to conduct an experiment on a larger scale to further learn on how thinking process and metacognitive skill play a role in writing. Furthermore, we will conduct an experiment to compare participants based on greater number of aspects including expertise domain, writing experience, and on different environment. To improve the framework, we plan to include an eye-tracking system and body temperature sensor to enhance behavior and reaction detection.

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Prototyping and Evaluation of a Web Application Supporting Tourists in Trouble and Emergency

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Abstract: In this study, we have developed a Web application for tourists to easily obtain necessary information on their smartphones in case of trouble and emergency so that they can enjoy sightseeing in unfamiliar lands without worry. Many tourists visit the area with its historical townscape. The old-fashioned townscape sometimes makes it difficult for unfamiliar tourists to know what to do when they are in trouble. To solve this problem, our application has functions to display the current location, shelters, AEDs, contact information when they need help and some tidbits for disaster countermeasures. We conducted a demonstration experiment in the Hizen Hamashuku district of Kashima City, Saga Prefecture, Japan where we have been researching as a model district. As a result, we were able to evaluate the provision of information that would be useful in trouble and emergency for tourists and clarify future issues.

Keywords: Web application, for tourists, trouble-solving information, information for emergencies

1. Introduction

Various efforts related to safety and security have been carried out (ICTDSE2021 in ICCE2021, 2021; Mitsuhara, H., 2018). Most of them are for the area where they live. In unfamiliar lands such as travel destinations, it is necessary to prepare for other problems as well as disaster prevention in the area. Information provision and research have been conducted to enjoy a trip safely (Japan Tourism Agency,2022; Heum, P., 2017).

Old-fashioned streets are popular tourist destination (Japan Guide.com, 2012). Practical efforts are also being made for disaster prevention and mitigation in these historical cities and towns (Srinurak,N et al, 2021). Besides natural disasters, however, such areas have the following problems due to the old-fashioned streets. They are (1) less information display, (2) experience might not be helpful and (3) less people to help. In order for tourists to enjoy sightseeing with peace of mind without feeling such anxiety, we examined countermeasures, developed an application that supports tourists' peace of mind, and conducted a demonstration experiment focusing on troubleshooting during normal sightseeing, not during disasters. We considered providing information for that purpose and developed an application that supports tourists in trouble and emergency.

We conducted a demonstration experiment of the application to clarify its effect and challenges of information provision that would be useful in trouble and emergency for tourists unfamiliar with the area. The target area is Hizen Hamashuku district of Kashima City, Saga Prefecture, which is working to revitalize the town by utilizing its historical townscape and good old local culture (Agency for Cultural Affairs, 2017; Saga Trip Genius, 2014).

We have been collaborating with the voluntary disaster prevention organizations in this area to carry out activities for disaster prevention in the area and create a regional safety map(Okazaki, Y. et al., 2020). In this research, instead of providing tourists with such danger information of natural disasters, we consider providing information that will lead to the peace of mind of tourists.

2. Consideration of information to be provided through Discussion Meeting

2.1 Outline of Meeting

We held a discussion meeting with people involved in local tourism about the information to be provided to tourists. It was held for about two hours from 10:00 am on November 2, 2021. Participants are a total of eight people, including two of us(Saga University), three members of the district town revitalization group (Hizen Hamashuku Mizu to Machinami no Kai), and three staff members of the Kashima City Tourism Division and the Tourism Association. Based on the draft plan we prepared in advance, we examined the content of information to be provided to tourists and the method of providing it.

2.2 Basic Policy for providing Information

It is essential for tourists to enjoy sightseeing with safe, secure and peace of mind. Initially, we were thinking of providing tourists with the local danger information we had collected so far. This is because we thought that detailed regional danger information that was not presented on a hazard map for a wide area would be useful for travelers as well. From the perspective of disaster prevention and risk reduction, that is certainly the case. On the other hand, from the standpoint of tourism, there was concern that providing information about disasters would cause anxiety. The dangers in this area are low and there is little danger information that requires daily attention. Reiterating the dangers of disasters that travelers rarely encounter, such as heavy rains and earthquakes, only gives travelers anxiety and has a negative impact on tourism. Based on these considerations, we decided to provide information that would help travelers in case of troubles and problems during their stay, rather than disaster information.

2.3 Summary of information in Collaboration with the Local Community

We discussed what kind of information should be provided so that tourists can enjoy sightseeing with peace of mind. At the meeting, various opinions were given from the perspectives of disaster prevention and tourism. They are summarized in the following four.

1.Where are the tourists in the area now? What's around it?
We conclude that these can be solved by providing a map similar to the tourist map distributed on paper at the tourist information center and showing the current location. We have decided to list information on toilets, bus stops, parking lots, major tourist destinations, restaurants and accommodations with the same symbols as the paper tourist map.

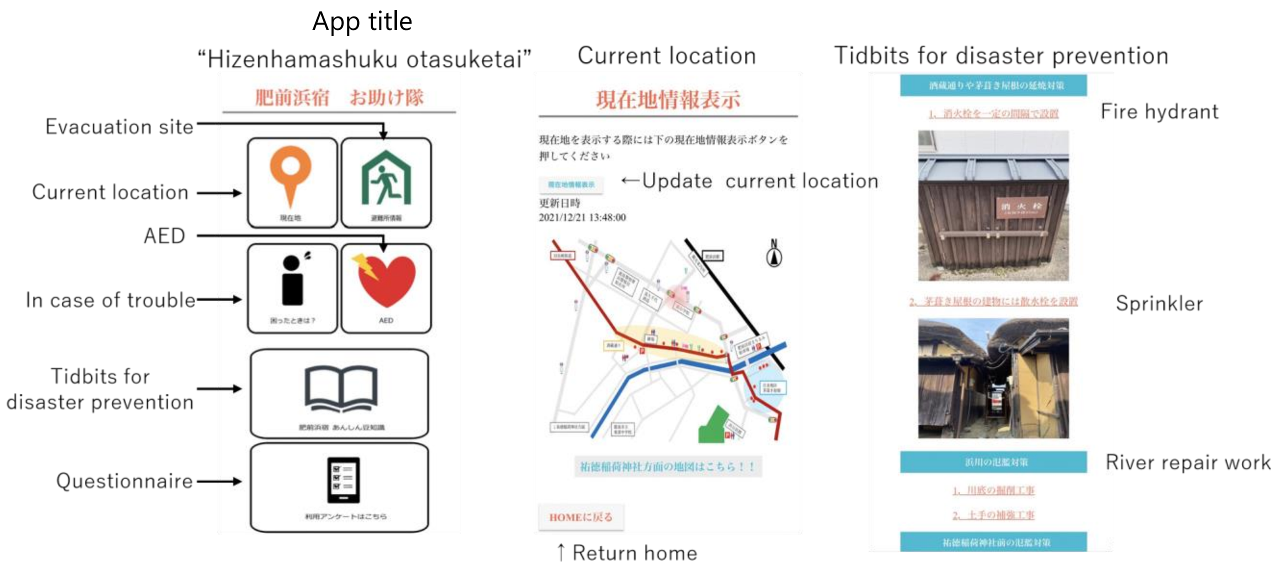
2. Where should tourists consult in case of trouble?
We conclude that this could be solved by providing two tourist information centers that support tourists and a police box in the district. In addition to the location, we decided to place a phone number button so that they could contact immediately.

3.What are the disaster prevention measures in this area?
Old-fashioned street districts are often vulnerable to disasters. Assuming tourists with such anxiety, we decided to provide evacuation site information (location and phone number) and some tidbits to introduce the disaster countermeasures in this area.

4.Where is the AED?
An automated external defibrillator (AED) is a device used in emergency medical situations. We have also decided to list all AED location in the district as important equipment used in case of life-threatening cardiac arrhythmias.

2.4 How to provide information

In response to the results of the examination, we decided to provide this information as a Web application. By using this app, we aim that tourists can get the information they need on their smartphone and easily solve it, and enjoy sightseeing with peace of mind even in unfamiliar lands.



(a) Main screen　　(b) Current location screen　　(c) Tidbits of disaster prevention

Figure 1. Screen of the application

Figure. 1(a) shows the main screen of this application. From this screen, user can access the current location information (Figure. 1(b)), evacuation shelter location information, emergency contact location, AED installation location, and tidbits to introduce the disaster countermeasures (Figure. 1 (c)).

The same schematic map as the map distributed by the tourist information center is used to provide the current location information. On the map, toilets, bus stops, parking lots, major tourist spots, restaurants, and accommodations are marked with the same symbol. Therefore, it is easy to correspond the map of the application with the map on paper. On the other hand, accurate position display by GPS is difficult. Therefore, we divide the map into 25 blocks, determine which block users are in from GPS information, and give approximate location information near the representative point of that block (Light red location in Figure 1. (b)). locations and contact information for all designated evacuation centers (three locations) in the area are provided on the map. This allows the user to know which shelter is nearby and to contact the location as needed.

For emergency contact in case of trouble, in addition to the two information centers and police boxes in the area, a telephone call button is available. Users can make a call immediately with a tap.

In the provision of AED installation locations, all AED installation locations (5 locations) in the region are shown on the map, Phone numbers are also provided so that users can contact those facilities.

Due to its age, the historical townscape area is worried about disaster prevention. By introducing local efforts for such disaster prevention, we believe that it will be possible to raise tourists' awareness of disaster prevention and reduce anxiety. It introduces a simple fire hydrant that can be used by one person to protect valuable historical buildings such as thatched roofs, and a sprinkler that is set as a measure against the spread of fire in thatched roof buildings. In addition, as a countermeasure against flood damage in the past, information on river improvement of the Hama River flowing through this area is introduced.

3. Evaluation Experiment

3.1 Experimental Method

Table.1 shows the outline of the experiment. With the cooperation of the tourist information center, we asked tourists who visit the area to try our application in their sightseeing and evaluate it. The period was about one month. We asked for cooperation in the experiment by attaching a leaflet with a QR code. In order to encourage participation, those who tried our application and answered the questionnaire were given a gift of Saga seaweed, which is one of the local specialties.

Table 1. *Outline of Evaluation Experiment*

Period	December 21, 2021 to January 31, 2022
Implementation Area	Hizen Hamashuku, Kashima City, Saga Prefecture, Japan (Visitors can enjoy walking and viewing the townscape from the Edo period.)
Leaflets Posting Locations	5 places (inside Hama Station, in front of Hama Station, next to Hama Elementary School, Machinami Parking Lot, Nakamachi Public Hall)
Number of Responses	18

Tourists who found a leaflet and wanted to use accesses the Web application by reading the QR code. And had them walk around the area freely. Table 2 shows the questions and answer options.

Table 2. *Questionnaire Item List*

Q1	Age group	Under 30s/ 40s to 60s/ 70s and above
Q2	Gender	Male/ Female/ Other
Q3	Number of Visits	First time/ 2nd time/ 3rd time or more
Q4	Contain the information required in an emergency?	Yes / Probably yes / Probably no / No
Q5	Feel relieved to have an app?	Yes / Probably yes / Probably no / No
Q6	Want to use?	Yes / Probably yes / Probably no / No
Q7	Easy-to-read screen?	Yes / Probably yes / Probably no / No
Q8	Easy to operate?	Yes / Probably yes / Probably no / No
Q9	Free description of desired information and functions	

3.2 Experimental Result

Figure 2. shows the experimental results. From the answers by age group(Q1) and gender(Q2), it can be said that there is no significant bias in age and gender among the participants in this experiment. According to the number of visits(Q3), more than two-thirds were three or more visitors, and the rest were first-time visitors. Most of the responses to the validity of the information(Q4) were positive. In

response to the relieved feeling that is the purpose of the app(Q5), half said they think so. All of them have positive opinions. So we can say that they appreciate the peace of mind by our app.

Regarding the use of the app, more than 40% answered that they wanted to use it(Q6), and three-quarters had a positive opinion. More than 80% answered the information is easy to see(Q7), and everyone is positive about the ease of operation(Q8). From these things, it can be said that the usability of the application is highly evaluated.

Regarding free description(Q9), there are opinions such as "The current location in the direction of Yutoku Shrine was difficult to understand", "I want more tourist information in connection with sightseeing tours", and "I think it is better to post it in more places"

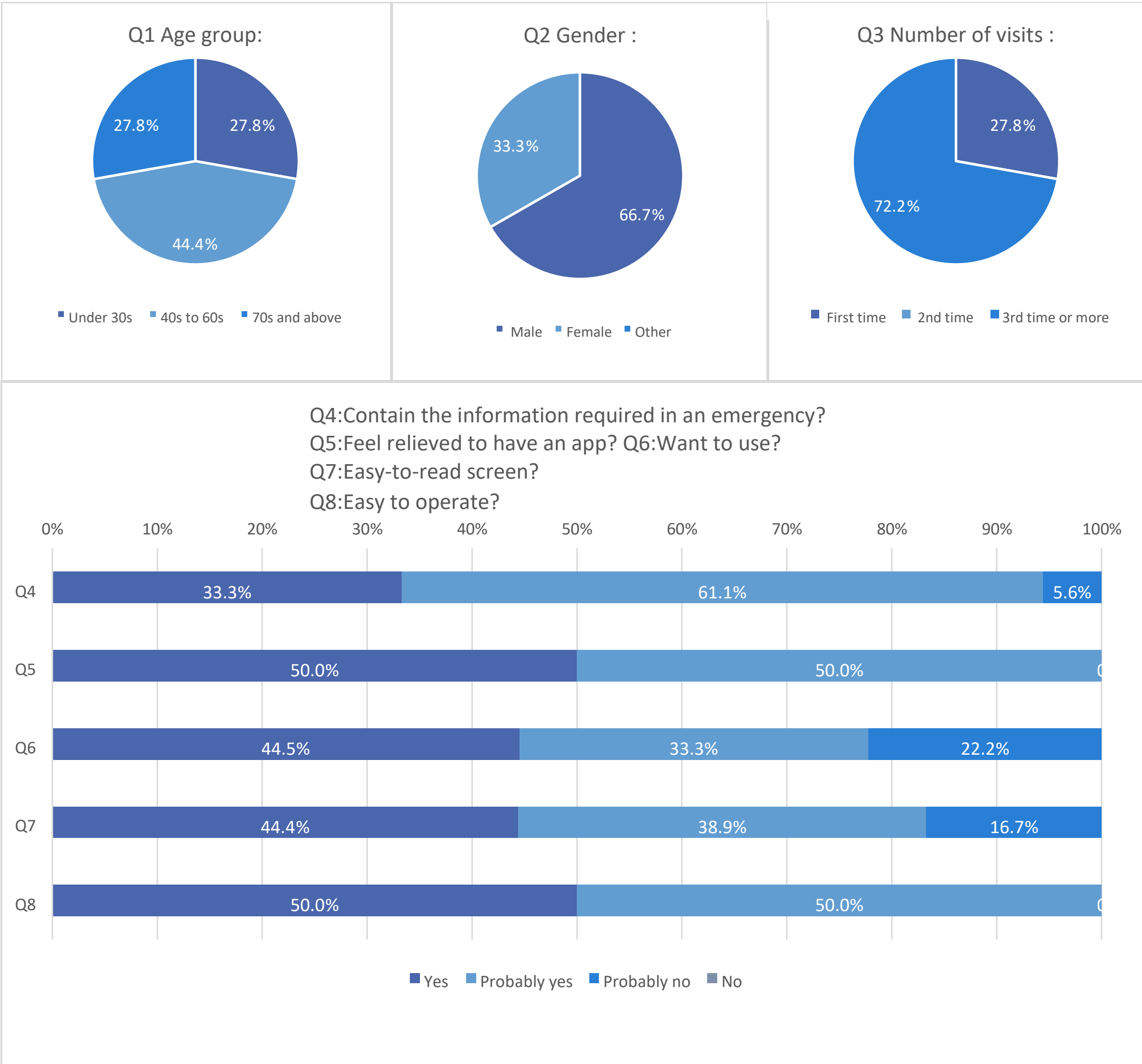


Figure 2. Questionnaire response results

3.3 Consideration

3.3.1 Usefulness

Consider whether they feel relief that is the purpose of our application. Of the five respondents who answered that they visited for the first time, three responded that they felt relief, and the remaining two responded that they felt rather. It can be said that it leads to the peace of mind of those who visit for the first time. Of the 13 respondents who said they had visited more than three times, about half of the six respondents said they felt relieved, and the remaining seven respondents said they would rather. From this, it was found that our application is effective not only for first-time tourists.

Next, we consider the usability of the app. Regarding whether they want to use it, three out of five people who answered that they visited for the first time, and five out of 13 people who answered that they visited three times or more answered that they would like to use it. On the other hand, the remaining two people who answered that they visited for the first time, and six out of three or more visits answered "I think it's rather", and two people answered "I don't think it's rather". In addition, more than 80% of the respondents answered affirmatively about the ease of viewing the app, and all responded positively about the operability, indicating that the app is evaluated as easy to use.

From these facts, it can be said that our application has been evaluated to a certain degree as an easy-to-use application that gives tourists a sense of relief. On the other hand, it was also suggested that some ingenuity was needed to get people to use it. As pointed out in the free description answer of Q9, this application is intended for troubles and does not include tourism purpose elements. The information that tourists want most is tourist information for visiting tourist spots. From the viewpoint of tourists' use, it is necessary to incorporate such a viewpoint of sightseeing tours.

3.3.2 Validity of Information

Regarding the validity of the information, out of the five people who answered that they visited for the first time, two people answered "I think" that they have the necessary information when they are in trouble, and the remaining three people think that it is rather. Of the 13 respondents who answered that they visited three or more times, four responded that they thought they had the necessary information when they were in trouble, and the remaining nine responded that they thought they would rather.

From these facts, it is considered that the necessary information is generally provided. On the other hand, as mentioned in the previous section, from the sightseeing point of view, the names and explanations of sightseeing spots will be added. Improving the provision of information in combination with tourism tour information is an issue for the future.

4. Summary and Future Works

In this research, in order to help tourists to visit tourist spots with peace of mind even in unfamiliar lands, we developed a Web application that provides necessary information in case of emergency and conducted an evaluation experiment. The developed app has a function to display the location information of the current location, shelter, AED, a function to display places and contacts that can be relied on in an emergency, and a function to introduce tidbits such as disaster countermeasures.

We conducted a demonstration experiment in the Hizen Hamashuku district of Kashima City, Saga Prefecture, Japan which was selected as a model district, for about a month to get tourists to use the app. As a result, it was shown that information that leads to the peace of mind of tourists, not just first-time tourists, can be provided in an easy-to-understand manner.

It is a future task to improve the provision of information together with tourist information so that it can be used not only in case of trouble but also for visiting tourist spots.

Acknowledgements

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Prototype System of Evacuation Training in Metaverse

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Abstract: The observation of users evacuating in a virtual reality (VR) earthquake simulator, in which a sudden significant earthquake occurred, indicated that paired users evacuated more methodically but with greater uncertainty than a single user. This discovery sparked curiosity regarding how a large number of people would react to a sudden earthquake in a virtual world. Therefore, we developed a prototype of an evacuation training in metaverse (ETM) system that integrates users' normal time (everyday life) with a simulated earthquake evacuation. In this work, we describe how to prototype the ETM system while demonstrating its requirements and techniques of implementation. Through this method, we hope to educate individuals on the significance of being prepared for unforeseen natural disasters like earthquakes.

Keywords: Metaverse, evacuation training, evacuation behaviors, earthquake simulator

1. Introduction

Natural disasters endanger humanity. Owing to the impossibility of predicting when and where earthquakes may occur, they are especially regarded as a significant threat. Since 2010, there have been approximately 190 earthquakes of magnitude 7.0 or higher globally (United States Geological Survey, 2022). In a country prone to earthquakes, for instance, the 2011 Tōhoku earthquake and tsunami (magnitude 9.0) caused approximately 20,000 fatalities. Consequently, individuals must be prepared for unexpected earthquakes. Generally, earthquake evacuation training requires participants to reach a safe location (e.g., a shelter) within a specified period of time. In Japan, earthquake evacuation training is regularly conducted in schools, businesses, and communities. In most instances, however, participants are notified of the start time of the evacuation training in advance. During the evacuation, they take predetermined actions (e.g., drop, cover, and hold on) while hearing a pseudoalarm. Then, they simply follow a predefined route to a safe location. Conventional earthquake evacuation training does not place participants in challenging situations (or does not require them to make difficult decisions) when evacuating. During a simulation of an earthquake amid heavy rain, for instance, participants must determine whether to evacuate to a shelter near a cliff, considering the risk of landslides. In other words, conventional earthquake evacuation training does not imitate actual earthquakes and should be more realistic in terms of simulated experiences.

Evacuation training has become more realistic owing to advances in information and communication technology. By depicting the arrival of a tsunami triggered by a catastrophic subduction-zone earthquake, for instance, a mobile application provides users with great engagement and training effect (Yamori & Sugiyama, 2020). Another mobile application with a geofencing framework makes evacuation training more realistic by presenting digital materials (e.g., a video and a single-choice question) that depict disaster scenarios (e.g., a fire and injured people) corresponding to specific areas (Mitsuhara et al., 2015). These mobile applications are utilized for outdoor evacuation training, their execution of which presents the following challenges:

- ★ It must ensure safety by preventing injuries and traffic accidents.
- ★ Because of severe weather, it cannot always be conducted (e.g., heavy rain).

Safety is a prerequisite for evacuation training, and simulating evacuation under different weather conditions can enhance training efficiency by providing simulated experiences of more complex evacuations. To overcome these challenges, virtual reality (VR) has been actively included in evacuation training to ensure safe execution regardless of the weather. Mobile application-based evacuation training is less immersive and engaging than VR-based evacuation training. For instance, a VR-based evacuation training system in which a participant evacuates from a fire accident in a 3D-modeled school while using a fire extinguisher (Mystakidis et al., 2022) was developed. Another system was developed to integrate various disasters, such as earthquakes, tsunamis, and fires, to enable simulations of disasters in more complex scenarios (Takeichi et al., 2018). Both systems mimic scenarios that are difficult to encounter in real life and are believed to provide participants with sufficient training benefits.

In recent years, the metaverse has garnered significant interest from several fields, including businesses, digital games, and education. The metaverse can be considered a vast virtual space where multiple users can communicate with others simultaneously as avatars, i.e., social/collaborative VR. VR has enabled the development of a cooperative training system for the efficient training of specific decision-making, wherein users interact with one another while responding to human-induced emergencies like explosions and shooting incidents in buildings (Sharma, 2020). Considering the possibilities of the metaverse, we developed a simple VR-based earthquake simulator in which a large earthquake suddenly occurs while users play a simple game in a virtual world. Observing users evacuate the scene revealed that, compared to a single user, paired users evacuated with caution but were confused (Mitsuhara et al., 2021). The findings sparked curiosity regarding how several individuals in a virtual world react to a sudden earthquake. Consequently, we proposed evacuation training in metaverse (ETM) and outlined the requirements for an ETM system focusing on earthquake evacuation (Mitsuhara & Shishibori, 2022). Accordingly, we prototyped the ETM system to meet these requirements.

This paper is organized as follows. Section 2 outlines the system design, including the requirements and a training model for evacuation. Section 3 describes how to develop the prototype while introducing the employed technology and software. Section 4 summarizes this study and outlines areas for further research.

2. System Design

The metaverse does not yet have fully acceptable definitions and standards. For instance, economic activities by users are required in certain metaverse services (such as Second Life) but not necessarily appropriate depending on the purpose (e.g., education). Because the ETM system's primary goal is education, it is not required to support economic activities. Focusing on metaverse implementation technology, as a minimum requirement, an ETM system must enable several users to interact simultaneously in a vast virtual world.

2.1 Requirements

In addition to the fundamental requirements, the ETM system must meet the following criteria for earthquake evacuation training.

Requirement 1: A comfortable virtual world

The ETM system should permit users to spend time in a pleasant virtual environment as an extension or component of their daily lives. Comfort can contribute to enticing users. For example, when dealing with earthquake evacuation training for university students, the ETM system offers users (students) a 3D-modeled campus where they can attend classes and interact with their peers. Depending on the users, gaming features may enhance comfort. A comfortable virtual world accentuates the advent of an unexpected earthquake.

Requirement 2: High-fidelity virtual world

From the perspective of earthquake evacuation training, the ETM system's virtual world should be identical to the real world. This is because if the virtual environment is significantly different from the real world, the training effects (e.g., knowledge acquired in the virtual world) may not contribute to a successful evacuation in the event of a real earthquake.

Requirement 3: Sudden earthquake

The ETM system should induce a sudden (unexpected) earthquake in the virtual environment while allowing users to live comfortably without earthquake concerns. In the real world, earthquakes strike without warning. The ETM system can make evacuation training more realistic by suddenly transforming a normal environment into an emergency scene. In contrast to conventional evacuation training, in which an imaginary earthquake is announced before the training begins, the ETM system can transform a normal period into an emergency.

Requirement 4: Reflection

The ETM system should enable users to reflect on their evacuation (e.g., route and decision-making) after training to enhance the training effect. In addition, reflection encourages users to consider how they should respond to an actual earthquake.

2.2 Evacuation Training Model

The ETM system switches from normal to emergency time mode in response to a sudden earthquake (trigger). In emergency mode, users can decide whether or not to evacuate. If an evacuation is required, every user begins an evacuation as a participant in an evacuation exercise. The evacuation training includes evacuation and reflection phases. Figure 1 depicts the transition between normal and emergency modes, illustrating whether or not users evacuate.

(1) Evacuation phase

A participant moves to a safe location. While en route, participants can interact and occasionally evacuate together. Observing users act normally and not evacuating may cause a participant to underestimate the magnitude of the earthquake and stop evacuating. In a real earthquake evacuation, some individuals do not evacuate despite the impending danger. To make disaster scenarios more realistic, the ETM system allows users to avoid evacuating.

If a predetermined time elapses (i.e., if the evacuation time limit is exceeded), the ETM system switches from an emergency time mode to a normal time mode. In other words, it is the end of the evacuation training. The ETM system considers a participant a successful evacuee if the individual reaches the designated safe location within the allotted time.

(2) Reflection phase

Participants should reflect on their evacuation after the training. It is critical for users to visualize their evacuations based on the log data (such as route and speed) to objectively reflect on the evacuation, even though the reflection method has not yet been determined. Moreover, visualizing the evacuations of other participants will promote objective reflection.

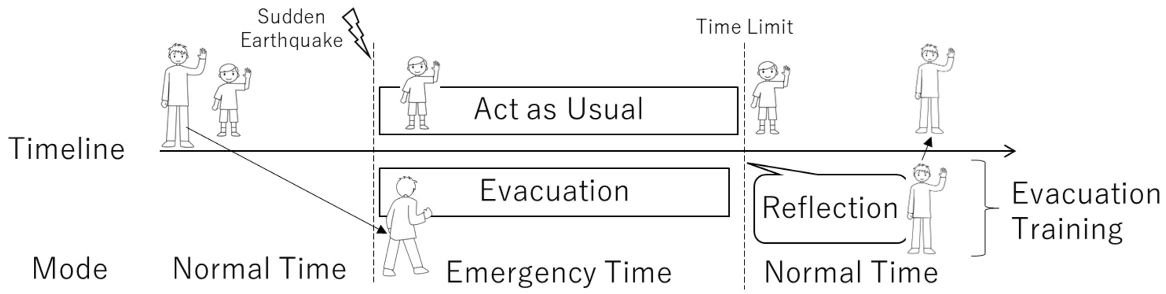

Figure 1. Evacuation training modes.

3. Prototype System

We adopted Unity as the prototyping environment because it enables efficient cross-platform software development (including VR) while utilizing the Assets Store, which contains several 3D models and scripts. We employed Meta Quest2, an immersive head-mounted display (HMD), as the principal VR device.

3.1 Multiple Users

Incorporating multiple simultaneous users is one of the ETM system's fundamental requirements and satisfies Requirement 1. Therefore, we adopted Photon, a network framework for Unity with stable connectivity even with a large number of connections, which enables the easy implementation of synchronous processing and essential metaverse functions (e.g., voice chat). We implemented these functions by adding several add-ons, including Photon Fusion and Photon Voice.

3.1.1 Implementing Simultaneous Users

Photon Fusion is utilized to enable multiple simultaneous user capability. First, the host computer (terminal PC) creates a room by connecting to the server on the Photon Cloud Network. When a room is created, the Photon Voice add-on is added to support voice chat within the room. The client computer then connects to the Photon Cloud Network and joins the room, allowing multiple users to enter the room simultaneously. This is accomplished by comparing the ID at the time of room creation to the ID at the time of joining. Currently, this ID is fixed. In addition, all objects set as Network Objects in the room are synchronized so that all client computers (i.e., users) can visualize the same environment.

The prototype system primarily renders static 3D models and only synchronizes the coordinates of the characters. Therefore, the processing is not computationally expensive, and it is expected that 2,000 users can simultaneously access the system (i.e., the maximum number provided by Photon). However, if the system moves 3D models such as chairs and desks during an earthquake, traffic between the host and client computers will undoubtedly increase. As a countermeasure, we want to reduce the number of polygons in the 3D models and the amount of data that must be synchronized.

3.1.2 Implementing a Nonplayer Character

Multiple users can access the virtual world and can engage in evacuation training using the ETM technology (i.e., take evacuation actions when a sudden earthquake). However, not all users enter the virtual world, and complex responses (e.g., panic and cognitive bias) produced by many users could not be simulated. Therefore, we implemented nonplayer characters (NPCs) that behave normally or evacuate during the emergency time mode. NPCs move based on the log data of previous users (i.e., movement data in or between buildings). When the time mode switches from normal to emergency, the ETM system searches the log data for the NPCs whose starting coordinates are closest to the present user, moves to those starting coordinates, and acts in accordance with the log data. We believe that these NPCs will make earthquake scenarios (evacuation) more realistic, even if there are few users. Figure 2 depicts a screenshot of NPCs moving in a room based on log data.

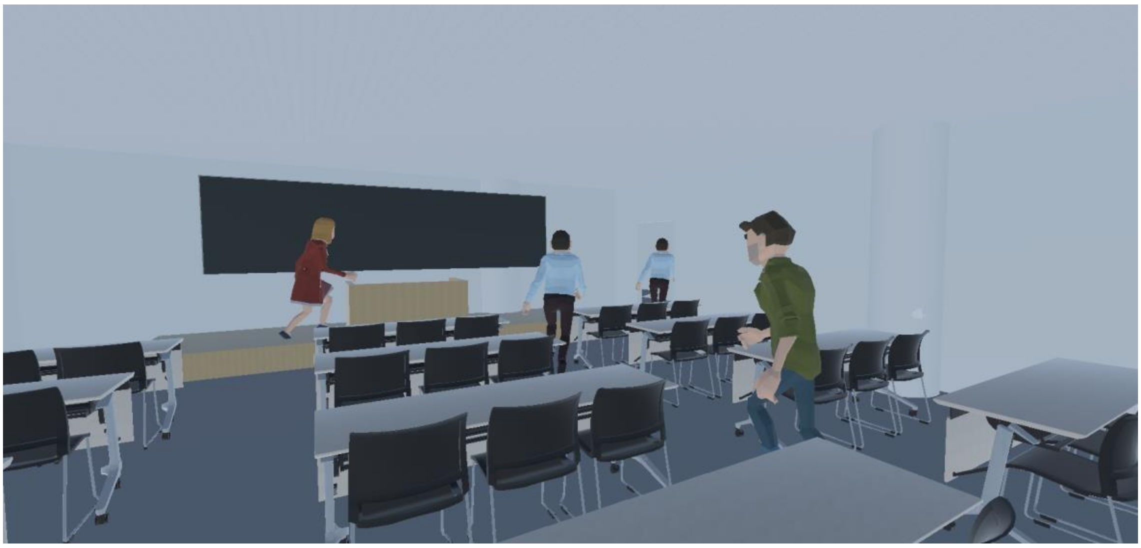

Figure 2. NPCs rendered in an emergency mode.

3.2 3D Modeling

The ETM system proposed in this study was employed for earthquake evacuation training on Tokushima University campus. To satisfy Requirement 2, we constructed a virtual world consisting of high-fidelity 3D models of the university campus using multiple software packages. The buildings were modeled in 3D using SketchUp Pro, a commercial 3D modeling application, and the outdoor landscape was modeled in 3D using Scaniverse, a 3D scanning application. Finally, the 3D-modeled outdoor scene was imported into Blender, a 3DCG creation software, for modification and integration. The 3D modeling process, including the application of each software, is outlined below.

3.2.1 Using SketchUp Pro

The process of creating a 3D model of a building consists of the following steps. Figure 3 shows a screenshot of the SketchUp Pro at the end of the fourth step.

1. Importing the building's architectural drawing data into SketchUp Pro.
2. Adjusting the 3D model to match real-world sizes.
3. Creating objects not available in the data (e.g., stairs).
4. Hollowing out the frames to create the windows and doors.
5. Pasting seamless images onto the walls, floors, and ceilings as the textures.

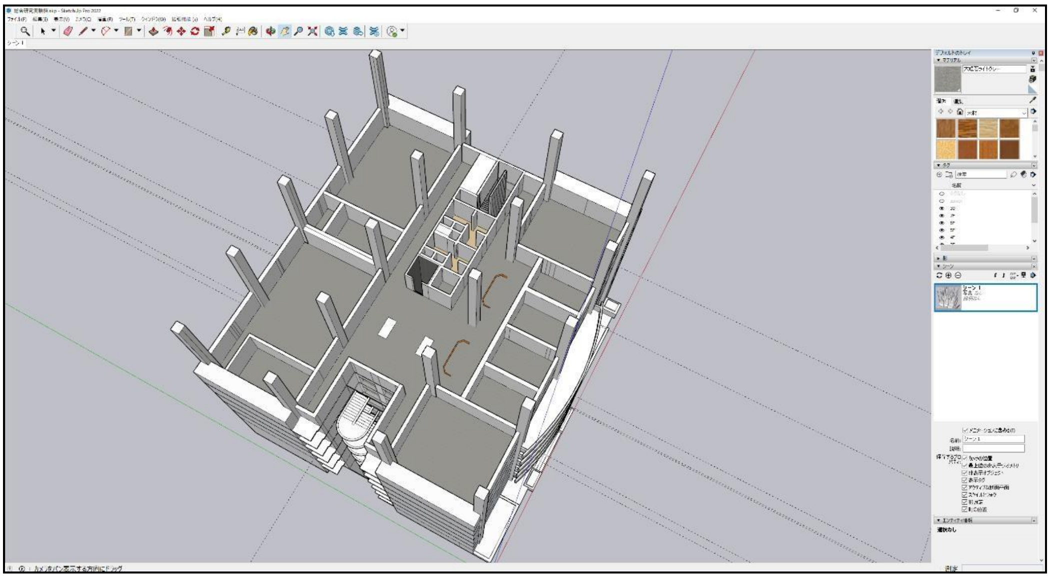

Figure 3. Scene view of the model in SketchUp Pro.

3.2.2 Using Scaniverse

Using photogrammetry, photorealistic 3D models of real-world objects have been created. Scaniverse is a popular photogrammetry program that works on a LiDAR sensor-equipped smartphone (such as iPhone 12 Pro) and simplifies 3D modeling using a visual prompt. Because 3D modeling of a large region at once would result in numerous distortions and breakdowns, we shot the campus in parts to eliminate the distortions and breakdowns. Figure 4 shows a screenshot of the university campus modeled in 3D by Scaniverse. For the efficient elimination, we have established the following guidelines.

- ★ Taking single shots. This is because shooting the same scene repeatedly would result in duplicate models.
- ★ All objects (areas) in a scene are shot once. Because complex shapes are difficult to repair when distorted.
- ★ Shooting a few objects that overlap with other models. When integrating models, it is necessary to match the locations of shot objects.

As depicted in Figure 4, the 3D model (i.e., the photorealistic part) was limited to scenes around the ground floor because the shots were taken from the ground. To model a tall building in 3D, we must shoot from a higher altitude by utilizing a drone or other equipment.

Figure 4. Scene view of the model in Scaniverse.

3.2.3 Using Blender

Scaniverse's 3D models (sections) cannot be utilized directly as the virtual world because of varying degrees of distortion. We utilized Blender to rectify the distortions and merge the individual 3D models. We corrected the 3D models based on the ground. If portions of the ground were duplicated, we removed one and shifted the vertices to level the height. If the 3D model is distorted, we cut only the distorted portions, reshape, and merge them into a single model. In both instances, we reshot those scenes if such corrections are too difficult to make. Merging the split 3D models is easy. Scaniverse creates 3D models using laser distance measurements and does not need to alter the sizes of 3D models, even if they are split or shot independently. Therefore, if appropriate corrections are made, the 3D models can be integrated by simply moving or rotating them.

Figure 5 depicts a before-and-after Scaniverse 3D model (section) of the corrected university campus. On the left side of this figure, the square area is distorted, whereas the area on the right was corrected.

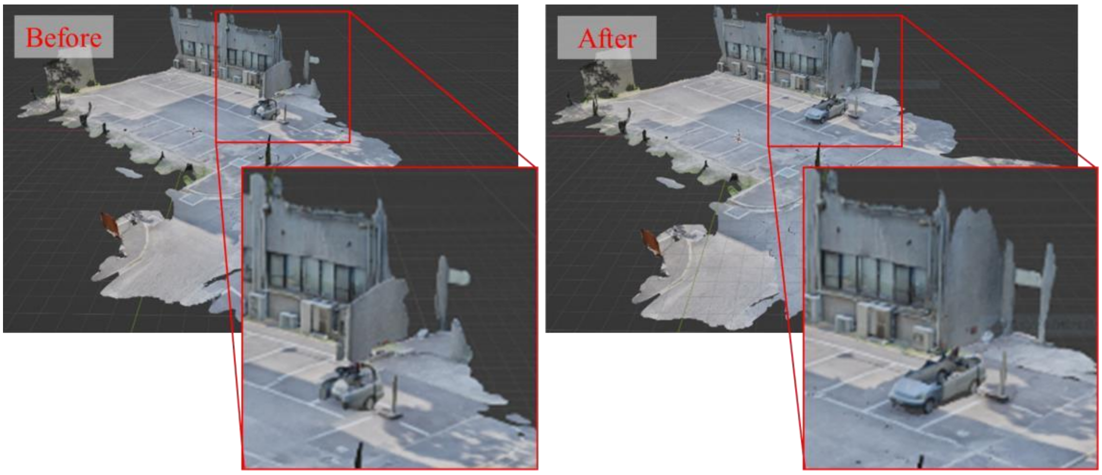

Figure 5. Before-and-after 3D model (created by Scaniverse) under correction.

3.2.4 Using Unity

The 3D models can be nearly completely generated using the above procedure (software usage). To effectively depict earthquake-induced disaster scenarios, however, extra modeling is required. Glass-paned windows and light objects should be broken or moved precisely by the tremors. We adopted Unity assets as 3D objects and placed them in the virtual world. On the basis of a physics calculation or assets' settings, the 3D objects could break or move.

3.3 System Flow

The ETM system performs evacuation training according to the steps outlined below. The third and fourth steps correlate to Requirement 3, whereas the sixth step corresponds to Requirement 4. Figure 6 depicts the evacuation training flowchart.

1. Opening a room and setting up a scenario

A host computer designated by the ETM system opens a Photon room and configures a user-selected or randomly selected scenario **2. Permitting entry into the room.**

Client computers (i.e., users) are allowed to enter the room. Nevertheless, the users are unaware of which scenario is implemented. The client computer downloads the scenario file from the host computer.

3. Obtaining earthquake information

The host computer obtains real-time earthquake information (in XML format) from the Japan Meteorological Agency.

4. Generating an earthquake in the virtual world

If an earthquake of magnitude 4.0 or more occurs in Japan (i.e., if such an earthquake is included in the received information), the host computer generates an earthquake equivalent to the real earthquake in the virtual world (i.e., shakes the virtual world) based on the scenario. It is worth noting that approximately one earthquake of magnitude 4 or higher occurred every week in 2021.

5. Expressing the destructive events caused by the earthquake

On the basis of the scenario, the destructive events caused by the earthquake (such as fire, debris, and injured person) are expressed in the virtual environment. In addition, events, including window shattering and the movement of light objects, are expressed based on physics computation or asset settings in Unity. When approaching a particular area, a user (a participant in evacuation training) will observe the event and will then be prompted to consider how to respond. Evacuation training (emergency mode) ends when the user reaches a safe location (e.g., a designated shelter) within the allotted time or fails to evacuate.

6. Providing reflection

Right after the evacuation training, the host computer prompts the user to reflect on the evacuation by observing the user's and/or other users' log data (e.g., evacuation routes and behaviors) and considers how the user should evacuate. The user may discover his/her own concept (or belief) for successful evacuation (e.g., “Evacuate without caring about injured persons”).

7. Setting up another scenario

The host computer randomly configures a new scenario in the room.

When a date/time-specified scenario is due, the host computer begins shaking the virtual world. In addition, step 7 is ignored because it is a one-time event.

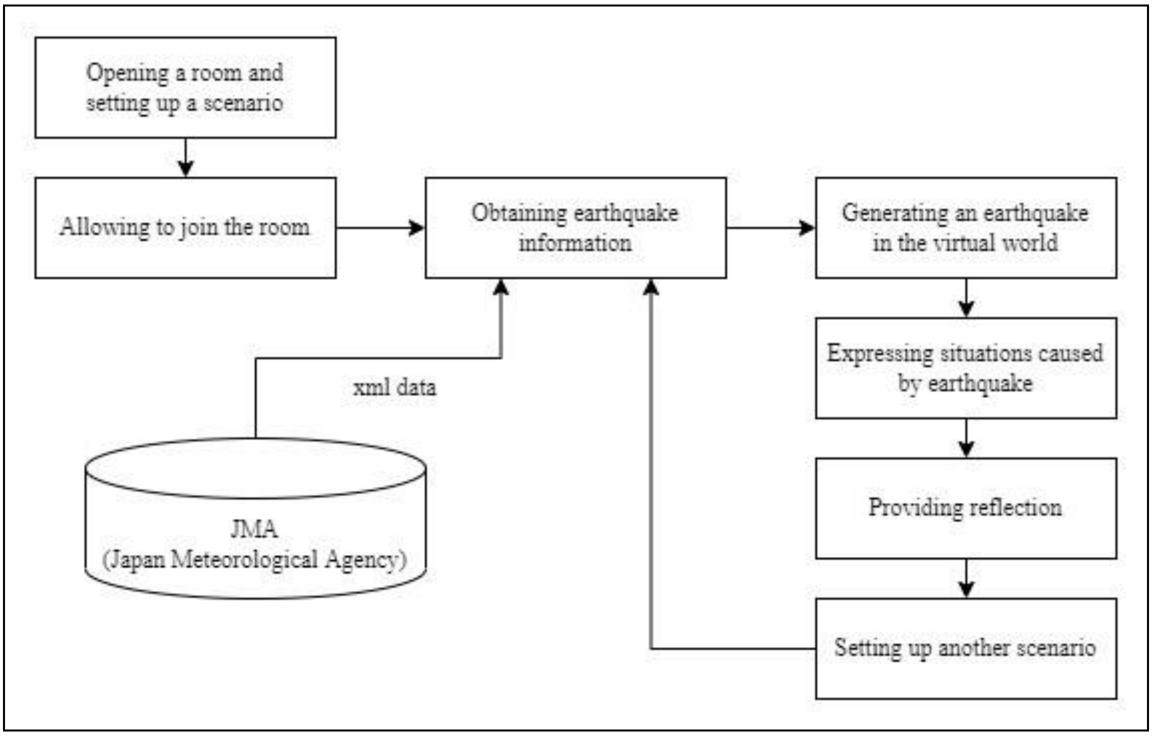

Figure 6. System flowchart.

4. Conclusion

This study discussed a proposed ETM prototype system designed for earthquake evacuation while demonstrating the requirements for evacuation training in metaverse. The prototype system adopted a more realistic and effective evacuation training by enabling multiple users (students) to simultaneously enter a high-fidelity virtual world (university campus). It is also equipped with sudden earthquake generation capability in the virtual world. In addition, the prototype system renders NPCs to compensate for the small number of simultaneous users. Multiple software packages, including SketchUp Pro, Scaniverse, and Blender, were utilized to generate 3D models.

Although the focus of this study is earthquakes, we believe that the established models and NPCs can be applied to other natural disasters. Typhoons, for instance, can be modeled in numerous virtual worlds through the audiovisual effects of heavy rain and strong winds (shaking trees). However, for disasters that do not occur in the modeled locations, it is better to reconstruct areas where they could occur to avoid unrealistic models. We also believe that new audiovisual effects (e.g., programmed animation) should be developed for various disaster scenarios (e.g., poor visibility and puddles in the case of heavy rain). To achieve realistic evacuation training, the scalability of the virtual world is also essential. In this study, we modeled a university campus as a relatively small virtual world, but generally, the metaverse is expected to provide a vast virtual world. Depending on the platform, a larger virtual world would increase human loads in 3D modeling and would make the ETM system more complex and computationally demanding (e.g., HMD and PC). Therefore, we should explore a virtual world that is sufficiently realistic and large enough for evacuation training.

To meet the requirements of the proposed model, a function enabling users to reflect on their evacuations (e.g., route) should be developed expeditiously. In addition, we must introduce attractive services that can entice users to routinely access the ETM system, where evacuation training can be suddenly executed by interrupting their normal lives.

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Immersive Function for Allocating Disaster Situations for a VR-based Evacuation Training System

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Abstract: In this paper, we describe an immersive function that annoys evacuation trainees by enabling an evacuation training designer, which is used to easily allocate disaster situations (e.g., fire and debris), in a virtual reality-based evacuation training system. This immersive function uses a head-mounted display and intuitive controllers to meet requirements, such as high immersiveness. Through a preliminary comparative experiment, we discovered that the immersive function can effectively annoy the trainees despite having insufficiency, such as weak expression of time-variable disaster situations.

Keywords: Disaster situations, evacuation training, head-mounted display, virtual reality

1. Introduction

We must prepare to survive unpredictable natural and artificial disasters. For example, evacuation training is common preparedness. However, traditional evacuation training is not always effective for successful evacuation during real disasters because of its monotonousness. Therefore, participants in traditional evacuation training must concentrate on following a predetermined evacuation route and will not be given opportunities to think regarding how to evacuate. Thus, evacuation training should make disaster situations expressed realistically to prompt thinking regarding how to evacuate. Real-world evacuation training has difficulty simulating disaster situations (e.g., fire and debris) to ensure participant safety. We must explore another evacuation training approach to eliminate this difficulty, and using virtual reality (VR) is a promising approach. VR-based evacuation training can ensure participant safety and can realistically express disaster situations in a virtual world.

It has been used in numerous instances (Khanal et al., 2022). In particular, it has been actively integrated into serious games. For example, an immersive VR serious game (IVRSG) for earthquake evacuation training promotes reflection-in-action while focusing on immediate feedback and spiral narratives (Feng et al., 2022). An IVRSG for school fire preparedness (e.g., evacuation and extinguisher usage) expresses fire emergency realistically using a cave automatic virtual environment and a fire dynamics simulator (Mystakidis et al., 2022). From another perspective, VR can be used to analyze human behavior for successful evacuation during disasters. For example, wayfinding behavior in a multilevel building was analyzed between head-mounted displays (HMD) and desktop VRs (Feng et al., 2022). Another research revealed that route choices during evacuation were affected by the behavior of their neighbors (Fu et al., 2021). Mitsuhara et al. (2021) focused on observing participant behavior during an earthquake in a virtual world. They prototyped a VR-earthquake-simulator system, where an earthquake suddenly occurred in a virtual world and disaster situations were generated at allocated locations (for fires) or based on a simple physical simulation (for objects scattered by shakes). Considering how to extend the prototype system to VR-based evacuation training, we found that disaster situations should be allocated at intended positions in the virtual world to annoy participants during evacuation. Such annoyance indicates that the participants encounter dangerous situations by prompting them to think of how to avoid these situations while making evacuation training impressive.

On the basis of this background, we implemented an immersive function for allocating disaster situations in a simple VR-based evacuation training system. In this function, an evacuation training designer wearing an HMD allocates disaster situations by pointing at the position using intuitive controllers.

2. Requirements

The immersive function aims to satisfy the following requirements that annoy participants during evacuation:

1. Providing high immersiveness.
2. Easily allocating disaster situations to intended positions.
3. Expressing time-variable disaster situations.

Requirement 1, which is satisfied using an HMD and intuitive controllers, is important because it allows an evacuation training designer to allocate disaster situations subjectively while making the designer feel like a participant. Requirement 2, which is related to Requirement 1, is satisfied by enabling the designer to point out the intended positions of disaster situations using controllers. Requirement 3, which simulates real disaster situations (e.g., fire spread), is satisfied by designating time-variable data to disaster situations.

3. Function Overview

We adopted Oculus (/Meta) Quest 2 as the HMD and intuitive controller. The implementing environment was Unity with tool sets or assets, such as Android Software Development Kit, Native Development Kit, Java Development Kit, and Oculus Integration.

3.1. Virtual World

A virtual world is required to allocate disaster situations. Currently, the immersive function focuses on outdoor evacuation training, where participants evacuate to a safe building. This means that a three dimensional (3D) city model with at least buildings and roads is required. However, creating such a 3D city model from scratch is difficult. Therefore, we adopt an open-data city model provided by the PLATEAU project, which is organized by the Ministry of Land, Infrastructure, Transport, and Tourism Japan (see https://www.mlit.go.jp/plateau/ for details). To optimize the city model for Oculus Quest 2, we transformed the city model to Filmbox format and performed mesh integration and polygon reduction for lightweight processing. Furthermore, we applied Occlusion Culling for minimum rendering when Unity rendered the city model.

3.2. Disaster Situations

The immersive function processes allocated disaster situations as a scenario associated with a virtual world. The scenario is an aggregate of the allocated disaster situations. Each disaster situation has a position (x, y, and z in Unity coordinates) and a rotation angle in the scenario. The immersive function provides six types of disaster situations (Table 1 and Figure 1). Each type can be allocated to the ground and/or building wall. Currently, only fire varies (slightly spread) according to time passage. This scenario is recorded as an Extensible Markup Language (XML) file and loaded later into the system.

Table 1. *Allocatable Disaster Situations*

Disaster Situation	Allocatable Position
Fire	Ground and Wall
Explosion	Ground and Wall
Injured Person	Ground
Rain (Rain Drops)	Ground
Smoke	Ground and Wall
Debris	Ground

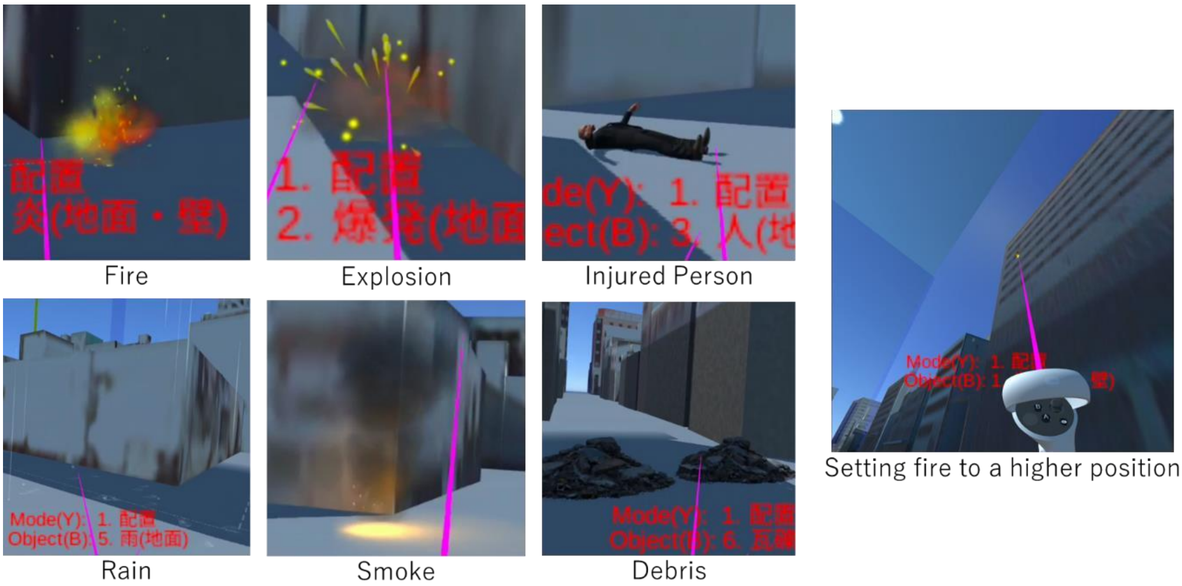


Figure 1. Screenshots of disaster situations allocated in a virtual world.

3.3. Usage

An evacuation training designer wears an Oculus Quest 2 and activates its immersive function. The designer allocates disaster situations along with the following flow:

1. Create a new scenario or select a loadable scenario.
2. Walk through the virtual world (corresponding to the scenario) by operating a joystick on the controllers.
3. Press the Y button to change the mode among *Allocate*, *Delete*, and *Instructions*. Currently, the immersive function allows the designer to only delete the last-minute allocated disaster situation. All disaster situations can be deleted by repeating this deletion.
4. Press the B button to select a disaster situation to be allocated.
5. Point the position to allocate the selected disaster situation inside the screen of the designer using laser pointers, which are emitted from the rendered bottom of the controllers. When allocating fire, explosion, or smoke to a higher position, the designer points the position upward (shown in the rightmost screenshot in Figure 1).
6. Press the A or X button to allocate the selected disaster situation. Disaster situations, such as fire, explosion, and rain, entail sounds that become louder as a participant moves closer to the disaster situation.

4. Preliminary Experiment

In February 2022, we conducted a small-scale preliminary comparative experiment at Tokushima University (a Japanese national university located in a coastal area facing the Pacific Ocean) to examine whether the immersive function performs as intended. In this experiment, a virtual world was created from the 3D city model of Numazu (a Japanese city located in a coastal area facing the Pacific Ocean), which was provided by the PLATEAU project.

4.1. Settings

4.1.1 Participants

The participants were 12 university students who were unfamiliar with disaster management or Numazu city. They were divided randomly into two groups:

- ★ Group A (N = 6): participants, as evacuation training designers, were required to allocate disaster situations to three areas in the virtual world.
- ★ Group B (N = 6): participants, as evacuation trainees, were required to evacuate from designated start to designated goal locations (safe buildings) in the three areas, which include disaster situations allocated by Group A participants.

4.1.2 Procedure

(1) Group A

Each of the Group A participants used three different allocation methods to allocate disaster situations in three areas.

- ★ Method A: they allocated disaster situations using the immersive function while wearing Oculus Quest 2 in a flat space of approximately 3 m × 3 m inside a soundproof room (Figure 2-a).
- ★ Method B: they allocated disaster situations using a desktop personal computer (i.e., the allocating function, which consists of a keyboard-and-mouse operable 3D view) and a general liquid crystal display (LCD), which are set in a student room of approximately 20 m × 5 m (Figure 2-b). They moved around the virtual world via keyboard operations. Then, they changed their eye direction and pointed to the allocating position via mouse operations.
- ★ Method C: they wrote disaster situations (e.g., fire and debris) on a paper Numazu map, which was set on a table in a soundproof room (Figure 2-c). They were allowed to allocate disaster situations only to the ground. We allocated the written disaster situations to the virtual world. A different area in Numazu city was assigned for each method. However, the linear distance between the start and goal locations was unified at 250 m for all areas. The area and the cityscapes had almost the same sizes. Group A participants were prompted to allocate disaster situations that could annoy evacuation trainees (i.e., Group B participants) in the VR-based evacuation training. Creating dead ends was allowed but not promoted.

To eliminate the order effect, each Group A participant completed the allocation tasks in a different order (Table 2). During the tasks, we video-recorded the screen for Methods A (Oculus Quest 2), B (LCD), and the map for Method C. There was no time limit to complete the tasks, and the participants answered a questionnaire after the tasks.

Table 2. *Order for Allocating Methods (Areas) Imposed on Group A Participants*

Participant	Order
A1	A ❼ B ❼ C
A2	A ❼ C ❼ B
A3	B ❼ A ❼ C
A4	B ❼ C ❼ A

A5	C ❼ A ❼ B
A6	C ❼ B ❼ A

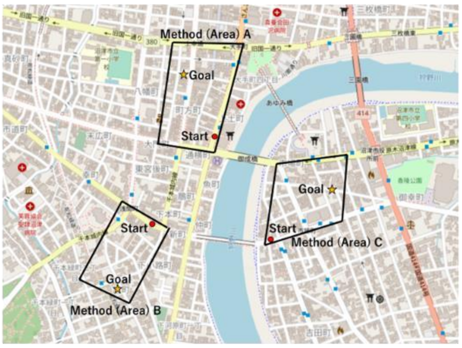
(2) Group B

Each of the Group B participants wore Oculus Quest 2 and performed evacuation (i.e., moved from the start to the goal location) in the three areas based on a sequential order to allocate methods (areas) similar to the corresponding participants. For example, participant B1, who corresponds to participant A1, completed evacuations in the sequential order of Methods A, B, and C (i.e., Areas A, B, and C). We video-recorded the screen of the Oculus Quest 2 during the evacuations. The participants answered a questionnaire regarding the evacuation each time they completed an evacuation. They responded to the questionnaire, which asked regarding the overall VR-based evacuation training, after completing the last evacuation.

a) Method A
(Immersive Function)

b) Method B
(Keyboard and LCD Display)

c) Method C
(Paper Map)



Areas by Method in Numazu City

Figure 2. Snapshots of the three allocation methods and the Numazu map that illustrates the areas.

4.2. Results

(1) Group A

Table 3 shows the quantitative data of the Group A participants in each allocation method. Task time duration (TTD) indicates the time (seconds) that each participant spent completing the allocation task. The number of allocated disaster situations (NADS) indicates how many disaster situations each participant provided in an area. The number of reallocation times (NRT) indicates how many disaster situations the participant deleted by quickly changing their positions. The mean values of TTD were 507.3, 413.1, and 239.0 s for Methods A, B, and C, respectively. Here the mean value of Method A was approximately twice that of Method C. The mean values of NADS were 77.5, 48.2, and 9.5 for Methods A, B, and C, respectively. Here, the mean value of Method A was approximately eight times that of Method C. The mean values of NRT were 5.5, 1.0, and 0, respectively. Here, the mean value of Method A was the highest.

Table 4 shows the results of the questionnaire given to Group A participants. The mean value of a five-degree Likert scale question (QA1) was 4.2. The mean ranks based on items (QA2–QA5) were remarkably inconsistent.

Table 3. *Quantitative Data for Group A Participants*

Participant	Method A (Area A)			Method B (Area B)			Method C (Area C)		
	TTD	NADS	NRT	TTD	NADS	NRT	TTD	NADS	NRT
A1	647	130	0	674	89	0	335	13	0
A2	939	168	29	573	73	2	397	9	0
A3	338	36	0	354	16	0	220	8	0
A4	459	8	5	372	30	0	143	9	0
A5	415	62	0	385	44	1	264	11	0
A6	246	61	0	121	37	3	75	7	0
Mean	507.3	77.5	5.5	413.1	48.2	1.0	239.0	9.5	0
SD	250.4	60.0	11.2	192.3	27.5	1.3	119.3	2.2	0

Table 4. *Questionnaire Results for Group A Participants*

Likert Scale Question (Option = 1: Strongly disagree, 2: Disagree, 3. Neutral, 4: Agree, 5: Strongly agree)	Mean
QA1. Do you think you allocated disaster situations that annoyed the evacuation trainees?	4.2

Mean rank by item

Please provide a rank (1–3) for the allocation methods.	Mean rank by methods		
	A	B	C
QA2. How about high immersiveness?	1.2	1.8	3.0
QA3. How about high operability?	1.8	1.8	2.0
QA4. How about highly easy?	2.2	1.8	1.5
QA5. How about high enjoyment?	1.5	1.8	2.5

(2) Group B

Table 5 shows the quantitative data of Group B participants for each allocation method. Evacuation time duration (ETD) indicates the time (seconds) that a participant spent to complete the evacuation. The number of disaster situation encounters (NDSEs) indicates how many disaster situations the participant observed during evacuation. We counted NDSE manually from the video-recorded screens, and two or more disaster situations allocated to the same position were counted as one disaster situation. The mean values of ETD were 148.1, 103.6, and 131.5 s for Methods A, B, and C, respectively. Here, the mean value of Method A was the highest. The mean values of NDSE were 5.7, 4.7, and 4.3 for Methods A, B, and C, respectively.

Table 6 shows the results of the questionnaire (five-degree Likert scale questions) given to Group B participants. The mean values of QB1, which was asked after completing each evacuation, were 3.7, 2.3, and 3.3 for Methods A, B, and C, respectively. Here, the mean value of Method A was the highest. The mean values of QB2–QB9, which were asked after completing the last evacuation, were higher than 3.0.

Table 5. *Quantitative Data of Group B Participants*

Participant	Method A (Area A)		Method B (Area B)		Method C (Area C)	
	ETD	NDSE	ETD	NDSE	ETD	NDSE
A1	140	13	117	8	109	5
A2	433	10	60	3	127	5
A3	118	3	67	3	63	5
A4	66	3	160	6	103	4
A5	67	2	171	5	280	5

A6	65	3	47	3	107	2
Mean	148.1	5.7	103.6	4.7	131.5	4.3
SD	143.0	4.6	53.5	2.1	75.7	1.2

Table 6. *Questionnaire Results for Group B Participants*

Likert Scale Question (Option = 1: Strongly disagree, 2: Disagree, 3. Neutral, 4: Agree, 5: Strongly agree)	Mean		
	A	B	C
QB1. Do you think you were annoyed until you reached the goal?	3.7	2.3	3.3

Likert Scale Question (Option = 1: Strongly disagree–5: Strongly agree)	Mean
QB2. Do you think you felt immersed during the evacuation training?	3.8
QB3. Do you think you felt urgent during the evacuation training?	3.2
QB4. Do you think you felt scared during the evacuation training?	3.7
QB5. Do you think you felt uneasy during the evacuation training?	3.3
QB6. Do you think you felt happy during the evacuation training?	3.5
QB7. Do you think you easily operated the first-person view avatar?	3.5
QB8. Do you think you comfortably viewed the screen?	4.2
QB9. Do you think you increased awareness of disaster management by participating in the evacuation training?	3.8

4.3. Consideration

(1) Group A

The mean values of all items in the quantitative data decreased on the order of Methods A, B, and C. For TTD, the mean value of Method C was remarkably lower than the values of Methods A and B. Although the low mean value indicates efficient allocation, the mean value of Method C was remarkably lower than the values of Methods A and B for NADS. These results may indicate that for Methods A and B, the participants concentrated on thinking and allocating disaster situations. The participants did not reallocate disaster situations for NRT in Method C. Although the mean values were not necessarily high even in Methods A and B, the former can be the easiest method to reallocate (i.e., allocate and delete) disaster situations. Because of the time of presenting QA1, we could not identify the method that was most effective for allocating annoying disaster situations. However, the high mean value indicates that every method made the participants feel capable of allocating disaster situations. This indicates that the quantitative data can be used to evaluate the methods. It can be determined from TTD and NADS that Group A participants required approximately 6.5, 8.6, and 26.5 s to allocate each disaster situation in Methods A, B, and C, respectively. Therefore, we assume that Methods A and B prompted the allocation, which resulted in an efficient allocation. However, Method C did not prompt or entail difficulty during the allocation.

For QA2–QA5, the mean ranks of Method B were moderate and those of Method A were better than those of Method C, except for the easiness of the allocation method (QA4). The mean ranks for operability (QA3) and easiness (QA4) of Method A were unfavorable. These results may have been caused by the difficulty of pointing out the position of a disaster situation. The unfavorable mean ranks in Group A may have occurred because the participants were prompted to consider how disaster situations should be allocated. Thus, Group A participants were taught how to annoy participants by allocating disaster situations. The unfavorable mean ranks will be evaluated differently from an efficient or effective perspective. Although writing on a paper is still easy even in the digital age, Methods A and B were superior to Method C in terms of TTD and NADS. Method A was not only the highest in TTD and NADS but also the best in terms of immersiveness (QA2) and enjoyment (QA5).

On this basis, we can conclude that Method A (i.e., the immersive function) was the most useful for the evacuation training designers to allocate disaster situations.

(2) Group B

For ETD and NDSE, the mean values showed no remarkable differences among the methods. Although the mean value for the NADS of Method C was the lowest, that of ETD of Method C was moderate. These results may depend on participant behavior (e.g., evacuation routes) and features (e.g., a sense of direction). However, Method C efficiently annoyed evacuation trainees despite the small NADS. For annoyance (QB1), the mean value of Method A was higher than the values of Methods B and C. This result may indicate that the high immersiveness in Method A made the evacuation training designers feel like they were evacuation trainees, thus resulting in allocating disaster situations that annoyed the trainees.

For QB2–QB9, the mean values were relatively favorable. The mean value of immersiveness (QB2) may have resulted from using the HMD. The mean value of scare (QB4) was slightly higher than the values of urgency (QB3) and uneasiness (QB5). Through free descriptions, we found just one comment expressing scare, which may have been caused by the immersive function: "*I was surprised when I turned a corner and found an injured person.*" We assume that this disaster situation may not have been allocated unless an evacuation training designer viewed it from the angle of a trainee. The mean values of enjoyment (QB6) and operation easiness (QB7) were moderate but acceptable. The high mean value of comfortability in viewing (QB8) may be caused by the performance of the HMD. Finally, the mean value of awareness for disaster management (QB9) was favorable. This may indicate that pseudo-evacuation experiences in the experiment can be enhanced via VR-based evacuation training.

From the above, we assume that Method C provided the most efficient evacuation training in annoying the trainees, and VR-based evacuation training can replace traditional (real-world) evacuation training or can be accepted as an alternative when conducting traditional evacuation training is difficult.

5. Conclusion

This paper describes an immersive function for allocating disaster situations that annoy evacuation trainees in VR-based evacuation training. The immersive function, which functions on Oculus Quest 2, was implemented to satisfy several requirements, such as providing high immersiveness, easily allocating disaster situations to intended positions, and expressing time-variable disaster situations. Through a small-scale preliminary comparative experiment, we concluded that the immersive function can satisfy immersiveness and can effectively annoy the trainees. However, the immersive function may have difficulty pointing to the position of a disaster situation as intended, which is insufficient to express time-variable disaster situations.

The experiment had limitations, such as few participants, narrow participant demographic information, and low questionnaire reliability. Therefore, to make effectiveness clearer, we must conduct a large-scale experiment with many participants and in more reliable settings. Furthermore, we must improve the immersive function and integrate it into our VR-based evacuation training. For example, the improved immersive function should help evacuation training designers configure disaster situations in detail (e.g., size, intensity, interaction, and animation). It may also be required to display a plane view (mini map) for the designers to grasp the big picture for allocating disaster situations in the city model.

We focused on examining whether the immersive function is useful for allocating disaster situations, but another focus is its usefulness in disaster education. We would like to examine its educational effect in our next experiment.

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Learning Affordances of a Facebook Community of Older Adults: A Netnographic Investigation during COVID-19

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Abstract: Current research in social media is heavily anchored on young individuals due to its wide acceptance in this social cluster. However, the trajectory of literature points to increased use of social media among older adults and a heightened interest in its community feature, especially during the COVID-19 pandemic. Facebook communities are online avenues that can portray the everyday lives of older adults in the absence of social participation during a pandemic. To compensate for this absence, older adults have joined, mingled, and interacted with various online communities to engage in learning opportunities. Using netnography, we analyzed 378 Facebook posts in a private community of older adults during the early months of the pandemic. We found that the learning affordances of a Facebook community include informal learning, knowledge dissemination, and information validation. The result of this study is helpful to various aged care stakeholders, including geriatric care, technology providers, and the academe.

Keywords: older adults, COVID-19, netnography, affordance, social media, Facebook

1. Introduction

Pandemics such as the Novel Coronavirus of 2019 or COVID-19 exacerbated adverse mental health effects in older adults due to a lack of social participation and community engagement (McKeon et al., 2021). Community lockdowns and mobility restrictions are non-medical interventions instituted by governments worldwide to curb the spread of COVID-19 (Dury et al., 2022; X. Zhao et al., 2020). While effective, especially in the absence of vaccines, these interventions can cause loneliness, boredom, and social isolation to older adults who value social engagement and participation as essential ingredients of meaningful late life (Freedman & Nicolle, 2020; Kulmala et al., 2021). Facebook is the preferred social media platform in the Philippines facilitating online engagements in various social process such as commerce and education (Esteves, 2012; Catedrilla, 2017; Catedrilla & Suarez, 2022). One of its popular features is its ability to establish online communities. A recent study has shown that older adults transitioned to online communities where they participate in social engagements online to buffer the adverse psychological effects of the pandemic (Hajek & König, 2021).

Online communities are public spheres where members can engage in online discourses with like-minded people. To understand older adults' participation in online communities, research must look beyond the technological artifact and consider the users' environment, goals, and possible uses in what is termed as affordances (Dhir et al., 2017; Jaidka et al., 2021). Despite evidence that older adults subscribe to lifelong learning in offline and online environments for overall psychological well-being, research has yet to uncover how online communities support late-life learning, especially during a pandemic (Benvenuti et al., 2020; Morrison et al., 2020). Given that most social media users are young, learning affordances or uses of social media for education during the pandemic primarily targeted university students and faculty members (Cavus et al., 2021).

Online discourses and social media data in an online community are rich inputs to studies that portray community practices, norms, and group sentiments (Franz et al., 2019; X. Zhao et al., 2020). This study aims to identify the various learning affordances of older adults during the early stages of the COVID-19 pandemic through netnography (Balcerzak & Nielek, 2017; Kozinets, 2019). We selected a

Facebook community, collected posts, and applied thematic analysis using the affordance theory. We add to existing scholarly works on social media literature and late-life scholarship in three possible underexplored areas. First, we widen the scope of research in social media use by conducting netnographic research in a Facebook community of older adults. Most studies have focused on the general use of Facebook, and its community feature that older adult use remains understudied (Hafezieh & Eshraghian, 2017; Newman et al., 2019). Second, we analyzed COVID-19 user-generated content to present a contextual understanding of how the pandemic stimulated online learning among older adults through a Facebook community platform. (Zhao et al., 2022). Lastly, our method allowed us to collect archival data through the social media discourses within the platform from the early stages of the pandemic. To add variety to the methodological approaches in the use of social media by older adults, we operationalized a sociocultural approach in the formation of themes through consideration of the community, its members, and the time at which data was shared on the platform (Rolandi et al., 2020). The results of our analysis will guide future disaster preparedness initiatives using the learning affordances of Facebook from the standpoint of older adults.

2. Related Studies and Affordance Theory

Social media has been extensively used in crises within and outside the classroom. We begin this section by presenting prior studies that explored how these platforms played a significant role during pandemics prior to COVID-19. Given the increased use of social media during COVID-19, we reviewed recent literature on how these platforms were utilized among various social groups, including older adults. As our objective is to present Facebook as a learning tool, we discuss the affordance theory applied to social media and its applicability to our study.

Prior pandemics have shown that social media is an authentic data source for understanding public emotions (Tang et al., 2018). The study of (Ahmed et al., 2018) of an extensive data set from Twitter revealed that social media platforms could reflect public sentiments and heightened curiosity during the Ebola and swine flu outbreaks. In their study, tweets were also used by Tran & Lee (2016), which revealed that social ties play an essential role in the propagation of information related to the Ebola outbreak. On the other hand, Facebook was also found to be an effective tool for crisis communication. During the Zika virus outbreak, Facebook posts were analyzed by (Sharma et al., 2017), and they found that posts were generally helpful in validating information. However, the same study also found that misinformation was more popular and generated more engagement than posts with validated information. These studies underscore the importance of social media data as an essential gauge of public perception during a pandemic.

During COVID-19, social media has become an essential source of information. For government and health authorities, Facebook, Twitter, and Weibo supported the fast dissemination of announcements, guidelines, and best practices to manage the crisis(Mori et al., 2021; Zhao et al., 2020). University closures disrupted how students learn, and Facebook provided the platform to sustain education (Corcuera & Alvarez, 2021). In the healthcare industry, medical students utilize Facebook to exchange learning materials and collaborate with faculty as part of their academic requirements (Bich Diep et al., 2021). Among medical professionals, familiarity with social media encouraged its use for remote teleconsultation to comply with pandemic restrictions (Doulias et al., 2022; Pagaling et al., 2022). A few studies investigated online groups and communities, such as the quantitative study of (Zhang et al., 2022) that found a positive attitude and increased engagement among participants during the pandemic and the work of (Mukattash et al., 2020) using content analysis of posts in a Facebook group of pharmacists.

The evolution of social media use from its original intent of establishing, connecting, and nurturing social ties to its present utilities of information dissemination and learning can be explained by the affordance theory of Gibson (2014). As applied in information systems research, affordances are perceived possible uses of a specific technology artifact. In social media, features that have been added, such as discussion forums, video chats, and anonymity, create affordances for different users (Jaidka et al., 2021). For online communities such as the Facebook community platform, unintended learning affordances include information dissemination and asynchronous learning (Barrot, 2021; X. Zhao et al., 2020).

3. Methodology

To gain deeper insights into the lived realities of the digital social world of older adults during the early stages of the pandemic, this study utilized the netnography approach of Kozinets (Belk et al., 2015; Kozinets, 2013). This methodological framework is appropriate for studies requiring a deeper understanding of an online community that will involve immersion of the researcher, observation of target participants, and gathering digital data to portray a detailed description of online community interactions (Fenton & Procter, 2019). The following sections describe our community, our data source, analysis technique.

3.1 The Facebook Community

Consistent with the traditions of ethnography, a Facebook Community was identified whose membership was limited to older adults residing in the Philippines referred. The decision to choose this community was motivated by its membership size (currently at 72,500 members), activeness (average of 60 daily), and years of establishment (5 years). The community administrator approved the membership of the primary researcher after explicitly stating his identity, intent, and research objectives. Ethical guidelines based on prior netnography studies on older adults were observed, such as approval of ethics clearance, acquiring informed consent, and keeping anonymity. Community immersion is one of the hallmarks of ethnography, whether conducted online or offline. The researcher joined the community six months before the pandemic to observe the members' customs, norms, and behavior.

3.2 Participants and Social Media Data

Archival data is an essential ingredient of ethnographic research, and in digital spaces, this takes the form of posts, comments, and reactions. We purposively identified 7 participants and collected their posts in the Facebook community from the start of the community lockdown until the end of May of 2020. This period represents a phase of the pandemic where the Philippines enforced movement restrictions, especially for older adults. This is the same period in the community where members actively interacted with fellow older adults. The data set comprises 386 posts categorized into 178 purely text-based, 125 texts with images, and 83 texts with images of an actual person. All participants are 60 years old and above as they are considered as older adults in the context of the Philippines. The demographic profiles of our participants are shown in Table 1.

Table 1. *Profiles of the Participants*

Participant	Member Since	Gender	Age	Community Affiliation
001	July, 2019	Female	62	Member
002	September, 2018	Female	68	Member
003	September, 2019	Female	63	Moderator
004	July, 2019	Male	71	Member
005	May, 2019	Male	67	Member
006	January, 2019	Female	65	Member
007	September, 2019	Male	60	Member

3.3 Thematic Qualitative Analysis of Social Media Data

The principal researcher approached the participants via digital or mobile means and explained the study's overall objective, the informed consent contents, and the data we required for the research. We collected the posts from the participants through manual extractions from the Facebook community for three reasons. First, while automated tools are available for public groups, we were restricted by the privacy type of the group. Second, collecting social media data from the entire group may deviate from what was agreed between the primary researcher and the community administrator. Lastly, while prior research suggested divulging the researcher's identity to the entire group to get permission to collect data, this may not be suitable for this study as the primary researcher is not an older adult, which may influence behavior within the community (Jeffrey et al., 2019). Our objective is to represent the online culture in its authentic form based on unbiased conversations within the platform.

To ensure an objective analysis for this study, we utilized an initial codebook from available literature and preliminarily arranged it based on the theoretical underpinnings of affordances theory (Balcerzak & Nielek, 2017; Roberts et al., 2019). Given the nature of the data we collected, we relied heavily on the observation notes of the primary researcher to come up with codes that are related to COVID-19. Examples of codes from prior research include "loneliness," "grief" and "fear," while codes from observation notes include "scare from COVID-19" and "fake news". The collected social media data was uploaded in a computer-aided qualitative data analysis software, or CAQDAS, called Dedoose (Andalibi & Flood, 2021; Shin & Hickey, 2021). This platform allowed the researchers to apply codes in excerpts of text-based and image-based social media data. Consensus agreement was followed in the application of codes guided by memos representing reflections of the researchers on the meanings of specific excerpts. We came up with themes from the code co-occurrence feature of Dedoose; these are frequencies of codes appearing together in the same social media post (Armborst, 2017; Kordzadeh & Young, 2018). Lastly, we selected exemplars for each theme to further elaborate our findings. We interpreted the themes and their corresponding codes in the context of our research participants, the site, and the lens of the affordance theory. Using a codebook, documenting reflections in memos, consensus coding, and presentation of exemplars, we adhered to trustworthiness for the authentic presentation of our qualitative study results.

4. Results

Compelling evidence in the literature points to social isolation among older adults as a catalyst for problems related to health and psychological well-being (Barbosa Neves et al., 2014). In the Philippines, evidence of its effects on the aging population is insufficient, owing to its culture of care and that majority of older adults are community dwellers (Badana & Andel, 2018; Hofstede, 2019). COVID-19 brought unprecedented challenges to vulnerable groups, including older adults. Digital technologies during this health crisis can support the overall well-being of Filipino older adults (Buenaventura et al., 2020). During COVID-19, online communities can provide the necessary tool for information exchanges to promote learning to older adults without compromising their safety (Beaunoyer et al., 2020).

Community members are not used to social isolation, which is evident in the volume of posts and comments related to COVID-19 from March to May of 2020. In their conversations, they exchange information on government policies and concerns about COVID-19. A myriad of information on health advice, daily exercise, and diet recommendations. Participants also update each other by posting selfies and captioning it with information about how they cope with isolation.

4.1 Informal learning

The dramatic increase in the use of Facebook by older adults as a source of news information has been observed in recent literature. During the pandemic, media outlets and the government strengthened their presence on Facebook due to its wider reach and accessibility. Within the community, participants shared news information from media outlets and encouraged discussion among members. Some participants shared announcements by their local community leaders on the distribution of financial support, information on mobility restrictions, and updated COVID cases. Our first theme includes code co-occurrences of "news", "updates", "community announcements", "government information" and “pandemic”. As exemplars, participant 005 and participant 001 shared the following:

> Participant 005 took a screenshot of a post from a media company and reminded everyone in his post:
>
> *“COVID cases are rising and there are no available hospitals. Please be safe everyone!”*

> Participant 001 posted an announcement from the Department of Health:
>
> *"Fellow members, I am reminding you to always wear your mask and wash your hand. COVID strikes us hard because of our age”*

While research has traditionally portrayed older adults as heavily reliant on traditional media for news consumption, an uptick in the use of social media for pandemic information (Choudrie et al., 2021;

Sheldon et al., 2021). A recent synthesis of available literature highlighted that older adults seek and share medical information related to aging (Y. C. Zhao et al., 2022). This is beyond the original objective of Facebook as a platform to connect and socialize with friends and relatives, creating an informal learning affordance. As the pandemic evolved, related online information on COVID-19 piqued interest among older adults as ageism was prominent in social media (McCabe et al., 2021). Discussing news and information about the pandemic with fellow older adults will encourage participation and discussion that can foster social connections (D. Morrison & McCutheon, 2019; Nimrod, 2014).

4.2 Knowledge dissemination

Older adults were considered vulnerable to COVID-19, and governments worldwide implemented strict enforcement of rules that restricted their movements. As such, loneliness and boredom have been observed among older adults. Data collected from the community during the early months of the pandemic revealed that participants shared selfies and information on how they deal with social isolation. In our second theme, code co-occurrences are "boredom", "loneliness", "daily activity" and "healthy tips". We extracted sample posts from participant 003 and participant 007:

> Participant 003, a community moderator, shares a picture of herself exercising at home and posted:
>
> *"Eating banana, drinking turmeric plus proper diet and toper exercise to make our emmune system healthy ..one simple way of fighting. . CORONA VIRUS ."*

> Participant 007 regularly shares a picture of the food she prepared. In this post, she shared:
>
> *"Cooking makes me forget the stress of the pandemic. Today I cooked steamed milkfish with my homemade sauce since I cannot go out to eat. If you want my recipe I can share it with you.*

In the early months of the pandemic, health authorities emphasized the need to minimize mobility to prevent COVID transmission through community lockdowns. For community-dwelling older adults, this policy equates to losing social interactions, physical inactivity, and a lack of physical community involvement (Sun et al., 2021). As a platform, Facebook communities provided an avenue for older adults to share their daily activities voluntarily, creating an affordance for knowledge dissemination. For Filipino older adults who are not used to social isolation, social media has become a channel to combat the adverse psychological effects of the lockdown. Research argues that in late life, older adults value opportunities where they share their knowledge voluntarily, and Facebook has become an instrument for knowledge sharing during the pandemic (Dury et al., 2022). This volunteerism encourages social participation and community involvement that can serve as a compensatory buffer to the harmful effects of social isolation (Lee et al., 2015)

4.3 Information validation

While mainstream Facebook spaces have become a source of misinformation during the pandemic, the community served as an avenue to refute circulating online misinformation. Community members posted information captured in their timeline, shared it in the community, and explained why it is considered misinformation. Given the infancy of scientific information on COVID-19 and changing policies on community lockdowns, older adults resorted to the community as an avenue to invalidate online misinformation. Our last theme included code co-occurrences of "fake news", "fact-checking", "government information" and "expert advice". For this theme, participant 002 and participant 004 explain why a piece of information is a misinformation:

> Participant 002, shared an infographic from WHO referring to recent information on the virus origins circulating online:
>
> *"It is not true that COVID was deliberate. The DOH reported that according to WHO, origins of coronavirus is still unknown. We all just have to get our facts from reliable sources. Fellow seniors, do not share unverified information or the community admin might kick you out"*

Participant 004 shared a screenshot of an announcement from the Department of Health:

"Police and the armed forces have already spoken. The health authorites supported this. It is not true that by tomorrow, helicopters will spray pesticide to kill the virus. The government information is clear, PESTICIDES cannot kill corona."

A growing concern in the latter part of the pandemic was the proliferation of COVID-19 misinformation. Although Facebook and other social media platforms launched partnerships with fact-checking organizations to fight misinformation (Cotter et al., 2022; Wardle & Singerman, 2021), the early months of the pandemic saw older adults within the community sharing opinions and information to invalidate unverified online information. This affordance allowed a community of older adults to engage in fact-checking activities from the viewpoint of late life. Some members will share unverified information in the form of an inquiry that can be validated by others inviting a collective effort to fight misinformation. It has been found that older adults are most vulnerable to misinformation due to cognitive decline, but as they age, they rely on life experiences to assess whether a piece of online information requires further scrutiny (Brashier & Schacter, 2021).

5. Conclusion, Limitations, and Implications

Our qualitative inquiry using social media within an online community of older adults revealed that informal learning, knowledge dissemination, and fact-checking misinformation are learning affordances of the Facebook community platform during the COVID-19 pandemic. While our results strengthen prior research that social media goes beyond fostering social connections, our study limitations should be considered for future related investigations. First, our thematic results can be validated using quantitative studies to test whether these affordances influence the participation of our older adults in an online community. Second, while our objective was to capture learning affordances in the early phase of the pandemic, comparing how these have evolved with factors such as vaccine hesitancy and automated fact-checking features of Facebook being implemented will be interesting. Third, our participants are community-dwelling older adults, given that the study was conducted in the Philippines. Future studies can include similar Facebook communities within and outside the Philippines to explore more learning affordances to further our research findings. Future investigations can replicate our methodology to analyze a private Facebook community of older adults in a geriatric facility to provide a comparative analysis of learning affordance between these two groups. Lastly, other studies advocated for a multi-site netnography for better research reproducibility.

In this study, we found that Facebook communities can offer opportunities to participate in cognitive activities that compensate for the lack of social participation during the early stages of the pandemic. These are learning affordances that can be considered by stakeholders involved in aged care to craft social media-based interventions. We also found that older adults can collectively learn through computer-mediated communication via Facebook. Learning institutions can consider this modality an option in academic activities involving older adults as we slowly transition toward the new normal. Lastly, it will be timely to look beyond the ageist perspective of older adults as incapable of using social media platforms due to cognitive decline. As our study has established, older adults utilize Facebook to acquire, disseminate and validate online information. These learning affordances can be maximized to provide technology-enabled interventions against late-life cognitive decline.

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Identifying the Dimensions of Teachers' Digital Learning Agility in the Age of Exponential Technology Use

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Abstract: The volatile, uncertain, complex, and ambiguous (VUCA) world and IR4.0 developments forces drastic changes to sustain and provide quality education. When schools were shut down abruptly due to COVID-19, teachers were forced into emergency remote teaching, mostly by utilizing technologies but with little to no specific structure. In Malaysia, studies found that teachers struggled with technology ability especially in mastering technology applications. Due to limited experience in preparing electronic materials and using online platforms, teachers took the time to deliberate on the ways to teach online, causing delays in learning. Delays can be mitigated if teachers are agile. Agile teachers are capable to deal with new experience flexibly and rapidly by trying new behaviors and making quick adjustments so that new learning can be realized even when they do not know exactly what to do when they face unexpected challenges. This quality in teachers is important to curb learning loss especially when education was threatened by COVID-19. Reciprocally, technology plays an important role to promote Learning Agility among teachers, ensure sustainability and quality of learning, and forge learners' engagement. With the exponential use of technologies, teachers need to be an agile classroom leader. This study aims at identifying the dimensions that shape teachers' Digital Learning Agility. We hoped that this proposed research can shed insights on digital learning agility and can improve teachers' performance especially in the age of exponential technology use.

Keywords: digital learning agility, technology competence, emergency remote teaching, teachers' performance

1. Introduction

Volatile, uncertain, complex and ambiguous (VUCA) is the defining characteristics of today's world. The COVID-19 pandemic had forced schools worldwide to shut down and emergency remote teaching ensued (UNESCO, 2022). While the pandemic had hampered several initiatives in education, in retrospect, it had accelerated technology adoption. However, the adoption fell short as most teachers were unprepared and insufficiently equipped with the necessary technological knowledge. Technology ability is a growing challenge among teachers in Malaysia when education was threatened by COVID-19. This is due to their limited experience in preparing electronic materials and using online platforms prior to the pandemic (Chin, Jiew & Al Jupri, 2022). Chin et al. added, their inability to response quickly to the drastic changes in online learning has caused learning delays, and to some extend, learning loss.

Despite the shortcomings of remote and online learning amid the pandemic, there were evidences of success. Scholars have suggested that teachers' agility could be on of the main factors that contributed to the success, despite their scarce technological knowledge. What makes them different? Agile teachers are willing to face a new experience with flexibility and speed because they know that students' learning are hinged by the teachers' competence. For instance, teachers are willing to try new practices and make quick adjustments so that learning can be realized even when they do not know exactly what to do when they face unexpected challenges.

2. Literature Review

2.1 Learning Agility: Of Flexibility and Speed

As the frontrunners of education, the teacher's role is paramount in ensuring the sustainability and quality of education. Moreover, with the emergence of the Digital Education Policy by the Malaysia Ministry of Education (Astro Awani, 2021), their roles as a strategic classroom leader became more apparent in ensuring the feasibility of the policy. With the challenges presented by VUCA and the rapid developments of IR4.0, teaching and learning is facing an unexpected transformation not only through methods and techniques, but steep growth of teachers' mindsets, instructional practices and knowledge orientation. Galés and Gallon (2019) asserted that the growing needs for a dynamic and flexible learning for every child necessitates a much more complex and enriched principles for teaching and learning, which consequently requires upskilling and reskilling among teachers. These resonate the aim of Malaysia Teachers' Standard 2.0 whereby teachers should be able to self-initiate their own professional development (Ministry of Education, 2019) to move forward.

Agility is well positioned to respond to uncertainty (Krotov, Junglas & Steel, 2015), thus this trait is much needed in the COVID-19 and other VUCA circumstances in Malaysia. Galés and Gallon (2019) vouched that an agile approach to teaching and learning in modern environment should be able to offer a flexible but structured situation that is ambidextrous to meet the growing needs of both teachers and students. Rutkiene and Ponomarenko (2019) emphasize the importance of teachers acquiring the ability to use modern digital technologies and equipment for information searching and lesson preparation. It is also imperative to note that an agile teacher not only should embody the skills but should be able to respond quickly especially when they are presented with new, complex, ambiguous and/or unfamiliar situations such as COVID-19.

Learning agility has long been discussed in organizational agility to ensure successful and effective performance, but not in the educational settings. Thus, this study aims to adopt and adapt this idea into the educational settings. Past scholars unanimously agreed that learning agility focuses on flexibility and speed (Burke, 2018; Mitchinson & Morris, 2014, & DeRue, 2012) that is characterized by learning enablers (which support individuals' learning agility) and derailers (which impede individuals' learning agility). According to Hoff and Burke (2017), an individual's ability to handle pressure and respond accordingly is an important factor in learning agility process. They added that people with higher learning agility scores perform better and would be more adaptable and willing to confront new, different, and unfamiliar demands.

According to the seminal work by Lombardo and Eichinger (2000), learning agility is defined as a person's ability and willingness to learn from their past and current experience, and adapt to new unfamiliar situation as a means to effectively perform at their workplace. Brown and Bessant (2003) define learning agility as an individual's capacity to identify and respond dexterously to opportunities that came from the unexpected changes in the situation that he/she is in. In short, it means that individuals who are quick to realize the opportunities that came with a novel situation and can strategize new plans has an upper hand in their performance as compared to their colleagues who are also affected by the similar situation but are not agile. Scholars also added that an agile individual can learn with speed and through a steep learning curve within a short period of time but can still deliver their tasks effectively and/or willing to take risks even if their decisions were not accurate due to the unfamiliarity of the situation they met (Burke, 2018; Mitchinson & Morris, 2014, Weber & Tarba, 2014; DeRue, 2012). Being able to handle pressure and respond accordingly is an important factor in learning agility process. Mitchinson and Morris (2014) visualized the Learning Agility Assessment Inventory as a framework that consist of four learning enablers and one learning derailer. Learning enablers are the mind-sets that will support learning agility. They are Innovating, Performing, Reflecting and Risking. However, learning derailer can hamper one's Learning Agility. Derailed mind-sets of derailed individuals are defensive and resilient to change. As such, they are not willing/unable to change and prefer to cling on to their past experiences that worked successfully in the past situations but could not work under the new circumstances. In addition to this, they refuse to grab opportunities even when they are presented with them (Harvey & DeMeuse, 2021) (Figure 1).

Figure 1. Learning Agility Enablers and Derailer (Mitchinson & Morris, 2014, p.3)

Lombardo and Eichinger (2000) came up with four interrelated facets of Learning Agility. They proposed that Learning Agility consists of People Agility (good interpersonal, learn from the past, treat others constructively, calm and resilient under pressure of new changes), Change Agility (curious, passionate, experimenting, upskilling/re-skilling), Results Agility (works best under pressure, inspire others to outperform, aspire others just by their presence), and Mental Agility (look at problems in retrospect, welcomes complex and ambiguous situations, iterating their minds to others). DeMeuse (2017) illustrates Lombardo and Eichinger's Learning Agility definition as shown in Figure 2.

Figure 2. The four interrelated facets of learning agility (DeMeuse, 2017, p. 270)

Mitchinson and Morris's (2014) Learning Agility Assessment Inventory and Burke's Learning Agility Assessment Inventory (2018) are two main framework available in the literature of learning agility. According to Mitchinson and Morris, learning agility is characterized by learning enablers that support learning agility and learning derailers that impede learning agility. They outlined four learning enablers, namely innovating, performing, reflecting, and risking. Meanwhile, defending is the only learning derailer. Burke (2018), on the other hand, outlined nine dimensions of learning agility focusing on behavior, namely flexibility, speed, experimenting, performance risk taking, interpersonal risk taking, collaborating, information gathering, feedback seeking, and reflecting. Some of these variables overlap with those proposed by Mitchinson and Morris (2014).

Ghosh, Muduli and Pingle (2020) postulated that learning agility is significantly related to outcome, namely performance. Therefore, this study aims to understand and identify the relationship between learning agility and teachers' perceived performance in their teaching and learning. Further to this, this study aims to determine the proportion of variance in teachers' perceived performance that can be explained by the learning enablers and derailers, and the relative significance of each in explaining teachers' perceived performance.

2.2 Teachers' Learning Agility

We can benefit from Warkentien's (2016) work, in which he viewed teachers as strategic classroom leaders. This resonates with the study by Howard (2017), who, on the other hand, studied learning agility among pre-service teachers. He vouched that as the main implementers of changes in the classroom, teachers need to possess the capacity to: (i) identify their students who encompass leadership skills in the classroom, (ii) facilitate the learning process, and (iii) lead and teach their students to see the opportunities brought in by new and unfamiliar situations. Howard added that learning agility is a good indicator of high potential, high performance, and long-term success.

In a much recent study by Nissim and Simon (2020), they found that a group of highly agile teachers who acted instantly during COVID-19 pandemic had facilitate the transfer of learning from face to face to online distance learning within 48 hours. Even though their initiative was imperfect, they managed to sustain learning rather than halting their students' learning momentum altogether and causes learning loss. In short, their ability to mitigate risks reflects their agility as teachers. Building on the literature on learning agility and teachers' agility, this forthcoming section discusses digital knowledge and competence and digital agility.

2.3 Digital Competencies and Digital Learning Agility

The basic means of digital learning agility lies in the notion that a person must have knowledge and competence in using technologies, and being able to response with speed and flexibility. This can be understood from the perspectives of teachers' digital competencies. According to Csordás (2020), people that possesses higher levels of digital competence are more productive. He postulated that workers with higher skills are able to create more benefits or able to deliver the same benefits in a shorter amount of time as compared to their counterparts who are not as skillful. This shows that it is evident a person's response time to a given situation is closely related to their competence in utilizing digital technologies, thus teachers' digital learning agility can be understood from their speed and flexibility in responding to uncertain circumstances that brings more benefit as compared to those who do not possess speed and flexibility. This is because those who are extremely familiar with technology often use a wide array of strategies with confidence, especially when their strategies involve the use of technologies (Csordás, 2020; Seal, Draffan and Wald (2010).

This includes their ability to change, customize, or personalize their technology use to serve different needs. Heavy users of technology often participate in online discussions, instant messaging, know how to use social networking platforms and frequently upload resources such as pictures or videos onto the Internet. They also know how to use search engines, access online learning materials related to their work, use word processors and spreadsheets, and optimize emails as a means of communication. According to Srivastana and Dey (2018) and Ghomi and Redecker (2019), teachers need to familiarize themselves with technological approaches and applications to achieve digital competencies. This can be done by keeping their digital technologies knowledge abreast and constantly engage in practices to personalize and create an interactive learning atmosphere for their students (Willis, Lynch & Fradale, 2019).

2.4 Teachers' performance

The majority of literature on Learning Agility focuses on workplace or organizational performance. To date, very limited studies on learning agility are found in the educational context, especially from the perspectives of Teachers' Performance. According to Fitria (2018), teachers' performance is "the result achieved by the teacher in carrying out the tasks assigned to him based on skills, experience and sincerity and the use of time." She added, teachers who demonstrate good performance will most likely improve the quality of their teaching and learning practices. According to Organization for Economic Cooperation and Development (OECD) (2020), the success of students hinge critically on their teachers' ability to help them navigate the online learning circumstances. Farooqi, Ahmed and Ashiq (2019) relate teachers' performance with their self-motivation. As such, teachers who are self-motivated and has positive outlook on themselves usually deliver vigorous teaching. This include efficient content delivery, as well as emphatically develop their students' characters.

3. Context, Purpose of the Study, and Methodology

This study will be conducted nationwide among Public Primary and Secondary School teachers in Malaysia. Borrowing Hoff and Burke's (2017) views in the Malaysian education context for this study, we hypothesize that teachers with high digital learning agility can cope and learn within a steep learning curve and respond effectively by taking ambidextrous opportunities and risks. This character will have a follow-on impact on their perceived teaching and learning performance and their students' learning.

This study is driven by these questions: (i) What are the dimensions that constitute Malaysian teachers' Digital Learning Agility? (ii) How do learning enabler(s) and derailer(s) contribute to teachers' teaching performance? (iii) To determine the relationship between teachers' digital learning agility and digital technology competency and teachers' perceived performance.

This study will employ an exploratory sequential mixed-method design that converges qualitative and quantitative techniques to produce rich and quality research findings (Creswell & Poth, 2017; Tashakkori & Teddlie, 2010). This approach is best in providing broad and in-depth understanding on Digital Learning Agility among school teachers in Malaysia. The data collection will begin with interviews with teachers and policy makers, to explore the possible dimensions of digital learning agility. At least three teachers and one policy maker will be interviewed from 13 states and three federal territories in Malaysia. Findings from the qualitative study will be thematized and used as constructs for the quantitative survey. A pilot study will be conducted prior to a nationwide survey which will be employed on primary and secondary school teachers from similar locations for qualitative study. Participants will be selected using the stratified cluster sampling technique on cluster basis (Creswell, 2015) to ensure optimum representation at each stratum.

4. Conclusion

In this study, we presented an overview of teachers' digital learning agility and related literature that pointed to the possibilities of its contributions towards teachers' performance. We also aim to identify the dimensions that shape teachers' digital learning agility and the learning enablers as well as derailers that could contribute to that. Based on the review of the related literature, we also theorized that there exist relationship between teachers' digital learning agility and digital technology competency and teachers' perceived performance. We hope that teachers and policymakers can benefit from this study by being able to reflect on their mindsets and motivation. By doing so, they will be able to make informed decisions and plan on their self-initiated professional and enhance their digital agility to face the VUCA of IR4.0. This framework serves as a guideline for policy makers, professional development providers, and administrators in the education settings to chart their plans for teachers' professional development that aligns with the exponential developments of IR4.0.

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A Systematic Review of Trends and Educational Research Issues of Digital-Supported Writing: A Promising English Learning Environment for Thai Higher Education

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Abstract: Due to the rapid development of digital support for both Artificial Intelligence (AI) and non-AI technologies, the current and future English language education is required to deal with these advancements and particularly enabling writingskills needed for higher education at the university level. The reason is that writing tends to be a difficult task for most students since it combines cognition and language utilization. In higher education, students must practice and apply English writing skills for their writing exams, projects, and papers for graduation or publication and preparethemselves for future work. The assistance from AI and non-AI technologies has a revolutionary role in supporting the English writing skills of students as well as helpingteachers during instruction. Therefore, this paper aims to review the academic papers which applied AI and non-AI technologies to enable English writing skills of university students, the reliability of these advancements, and their role of them as an assistant for writing skills, as well as guide how the features of AI technologies could use as learning strategies for university students in Thailand context.

Keywords: Quality education, higher education, technology-enhanced learning, language education, writing tools.

1. Introduction

The development of artificial intelligence and technology usage grew into the learning concepts of educational and writing skills in the English language with the utilization of Artificial Intelligence (AI) and technology platforms immersed in language learning. According to Su and Man (2019), AI has been extensively applied in numerous fields, including intellectual writing and evaluation in a second language. Writing skills is a challenging task for most students, and assistance from technology resources in higher education can help the learners be productive. Nickolaevna and Mekeko (2021) mention that even the traditional writing class is required technology resources for academic writing instruction.

The practice of AI and non-AI technology resources has become popular in various learning fields, and education in the 21st century could not escape from technology, especially in higher education studies. In the case of Klimova (2011), using information and communication technology (ICT) as a tool in students' English writing can improve their formal English academic writing since they are required to exploit Wikipedia as a reference source and expand the information to be published in a wiki website. This learning approach allows learners to acquire real academic writing experiences that they can learn and improve their writing simultaneously. Academic writing in English requires abilities to produce written works for graduating and publishing, which links applying to write professionally in the practical field of students' majors. Along with the advances of AI and non- AI technology, which can support academic writing for feedback, translations, and study sites, exploring AI and non-AI Technology enabled in academic English writing can be one issue to discuss in Englishwriting education.

Integrating innovative techniques in digital literacy helps students in higher education's learning process and supports it as a resource for students to improve their academic writing that can link to professional life. Linking digital literacy with professional life, Klimova (2011) points out that digital literacy in acquiring writing skills can help students in tourism management, finance, and information career fields. Additionally, technology is crucial in promoting students' writing, which canhelp them in the writing process. Hosseinpour, Biria, Reza& Ehsan (2019) identifies that using Edmodomobile application for academic writing proficiency in journal paper can promote students' motivation, self-esteem, and writing achievement. Automated writing evaluation (AWE), which provides automated feedback to students for revision, focuses on the wide use of AI in English writing.

Additionally, Automated Essay Grading (AEG) is extensively used around the world, and Su, Miao & Man (2019) mentions that AEG is applied widely due to a crucial role in the evaluation part of the Test of English as a Foreign Language (TOEFL). In the process of students' learning Academic English writing, the assistance of AI, such as Grammarly or relevant automated writing evaluation systems, can support them in revising writing correctly. Moreover, non-AI technologies, such as googleclassroom applications and the Facebook group, can provide a communication session and peer feedback to assist instruction while practicing writing.

Additionally, AI Writing Software can guide students' writing styles and learning strategies and develop motivation, constructivism, and cognition (Su et al., 2019). AI Intelligence writing software's role is crucial in assisting students to develop production quality since writing combines cognitive and psychological processes. Along with the important role of AI in academic writing, technology platforms also include a vital part in analyzing relevant research papers. The qualityof various genres in Academic English writing in higher education can be improved with digital support in terms of AI and non-AI technologies. Linking to the Thai universities' context in English writing skills, some learners are weak and find it difficult to English writing, especially in academic writing. According to Kawinkoonlasate (2021), by focusing on undergraduate students' English writing, learners face challenges in sentence structures, choices of words and vocabularies, and organization in paragraph structures, so utilizing AI or technology devices is vital for learners to promote learning results. Thus, to understand the practical trends in research of AI & non-AI technology in academic writing, insightfully updated literature on AI and technology platformsin Academic English writing from 2011 to 2022 is analyzed in this study leading to promising AI-enabled English writing skills in the Thailand context. In other words, this current study aims to promise a learning environment of English writing in the context of Thai higher education regarding the earlier trends and education research issues. The research questions have framed this study as follows:

(1) From 2011 to 2022, what are the nationalities, authors, and journals conducting the AI & non-AI technology in academic writing?
(2) From 2011 to 2022, what types of AI and technology devices are used in academic writing?
(3) From 2011 to 2022, what are application domains implementing AI & non-AI technology in academic writing?

(4) From 2011 to 2022, what are learning strategies applied to the AI & non-AI technology in academic writing?
(5) From 2011 to 2022, what are research methods conducted in AI & non-AI technology in academic writing?
(6) From 2011 to 2022, what are the results from research issues using AI & non-AI technology in academic writing?

2. Literature Review

The learning concept of academic writing in English with AI and technology platforms contributes immensely to a 21st-century education. As Lirola (2022) mentioned, practicing the written skill on a social media platform of the Facebook group not only enhances learning English writing but can also support obtaining social competencies for communication and cooperation. The role of English writing classes nowadays is not just teaching and giving students knowledge, but also the writing classes need to prepare students to develop writing skills. In order to progress written skills, AI, technology platforms, and tools take an important role as a part of the methodology in learning. It is why social media platforms and information and communication technology (ICT) situate as the main role in pedagogical purposes for updating education (Lin et al., 2016; Rwodzi et al., 2020).

Continuing the study of promoting academic writing with the usage of technology tools, the study by Saqr et al. (2021) uses the ENA web tool to analyze the writing strategies of students along with self-regulated learning (SRL) from the private Facebook group, which demonstrates how learners manage SRL in writing tasks for academic writing. The result of this study reveals that computer-supported collaborative learning in the context of academic writing can show the different SRL tactics of students in their argumentative essays. With the facilitation of technological applicationsand learning English writing, learners can realize their prior knowledge and obtain the new knowledgethat supports their writing structures. Furthermore, Chong (2021) indicates that testing students' prior knowledge through Google Forms with an online multiple-choice quiz can also reflect on the writing of the International English Language Testing System (IELTS).

Besides, giving feedback in learning English writing plays a significant role, and Taskiran & Goksel (2022) explore how feedback from the Write and Improve Software tool supports learners' writing achievement, along with the teacher's guidance, and feedback can be more effective f o r students writing. The important goal of applying AI and technology tools in students' writing can helplearners learn the correct writing structures from peers, and automated feedback assists teachers in guiding students for effective feedback. In addition, to guide for writing different academic essay genres and research papers, scholars also describe how technology software and applications can be used to foster academic writing (Mcculloch, 2017); Hosseinpour, Biria, & Rezvani (2019). The literature analysis is relatively scant based on the research analysis of AI and non-AI technology applications that enabled English academic writing. Therefore, to deliver a detailed literature analysis on AI and non-AI technology-enabled writing, the paper analyzes the literature to understand the findings of writing skills with AI & technology from eleven years ago and current research issues.

3. Research Methods

3.1 Resources

The journal papers related to digital support in English academic writing between 2011 and 2022 were searched in the Scopus database, including "academic writing" and "higher education" in the paper title, abstract, or keywords list. There were 76 papers published in International Journals and conferences relevant aiming to higher education. Among them, 14 papers were related to analyzing digital writing support for academic English. Three experienced researchers then read and categorized the papers based on the coding scheme to conclude the used papers, and there are 11 papers for this study, excluding policy-maker papers.

3.2 Data Distribution

The publication in digital support for AI and non-AI technology to assist in writing academic English papers from 2011 to 2022 is reviewed. It was found that, since 2011, the prospective action of Information and Communication Technology (ICT) as a tool can support and improve students' formal English writing in higher education (Klimova, 2011). In 2019, an investigation of the usage of AWE ina conference paper and argumentative writing was published by (Su, Miao, Liu & Man 2019). In addition, Quasi-experimental research with the mobile application Edmodo for blended learning of academic writing classes was discussed by (Hosseinpour, Biria, & Rezvani, 2019). Due to the improvements in technology, related papers in this field seem to appear more since English academic writing in higher education cannot escape from digital support as the tools of AI and non-AI technologies to gain and practice writing knowledge effectively anytime and anywhere. In 2022, three papers about the utilization of AWE and web-based argumentative writing to know students' behavior were explored by Talebinamvar and Zarabi's study. The research on using Facebook groups as learning management systems to learn grammar for academic writing and discussions for oral presentations is discussed by Martinez (2022). Besides, a study by Taskiran and Gokse (2022) applied to write and improve software along the social networking platform Facebook for descriptive writing tasks. The rapid growth of usage of digital support for both AI and non-AI technology seems to become the learning equipment of English writing for higher education.

3.3 Coding Schemes

The coding schemes of this study are adapted from the previous study of Chang & Hwang (2018), analyzing trends and research issues in nursing field education relevant to higher education in this paper. The coding schemes were adjusted because the coding scheme includes the nationality, authors, journals, adopted types of AI and technology-enabled writing, application domains with academic essay writing genres, learning strategies in technology used for accessing or measuring students' writing, research methods, and independent variables.

(1) Nationalities, authors, and journals: The purpose of discussing the basic information, including authors, nationality, and journals, is to realize who and which countries have more frequently published papers about AI and technology-enabled English writing in higher education.
(2) Adopted types of AI and technology devices: As suggested by Ouyang & Jiao (2021), the AI and technology here focus on (1) behaviorism of learners as the recipient, (2) cognitive and social constructivism of learners as a collaborator, (3) connectivism, and adaptive system of the learner as a leader is AWE tool and technology platforms in this study are, google classroom platform, Edmodo mobile application, Facebook group, and Wikipedia platforms.
(3) Application domains: The domains in this study refer to the genre of essays written in academic English, such as argumentative essays, descriptive writing tasks, opinion essays, conference papers, journal papers, and research papers.
(4) Learning strategies: The strategies of learning writing here focus on how many devices of AI and technology-enabled English writing are used for accessing or measuring students' writing. Wikipedia refers to accessing academic writing, supporting writing, and avoiding plagiarism. Automated writing evaluation (AWE) is a computerized assessment of written works utilizing natural language processing technologies for evaluating and analyzing students' writing. Epistemic Network Analysis (ENA) is a method for assessing and quantifying the relatedness of elements in coded data and restructuring them in dynamic network models to analyze students' self-regulated learning tactics for English academic writing. Blended learning through Edmodo mobile application is a teaching technique that combines the usage of technologies with traditional instructor-led classroom activities for accessing students' academic writing. Google Classroom is a blended learning platform developed by Google for educational purposes to facilitate students' academic writing. Facebook group is accessing students' writing and discussing among peers. An automated feedback system from writing and improving software is used for measuring students'

writing. Online multiple-choice quiz refers to the type of online assessment in which respondents are asked to choose correct answers from the options offered for testing students' knowledge.

(5) Research methods: This study reviewed research methods and participants and researched issues in AI and non-AI technology-enabled writing in Academic English of higher education. Research method categories are based on the methods explored by the researchers in this related field.

(6) Results from research issues: The cognition, effects, psychomotor and causal analysis are categorized in this study. Cognition refers to receiving knowledge from learning and affects the participants' feelings about learning. Besides, psychomotor present to the professional skills from writing and causal analysis means relationships or effectiveness in AI and non-AI technology-enabled writing.

4. Research Results

4.1 Nationalities, Authors, and Journals

There were many researchers from nine countries applying AI& technology-enabled writing in the field of higher education for academic English. The authors of the published papers are counted along with the nationalities of participants in each journal. From the data results, countries from Iran and Hong Kong have published two papers per each, and two journals from Iran (2019, 2022) were published in

Language testing in Asia and Turkish Online Journal of Distance Education-TOJDE. Two papers from Hong Kong (2021) were published in the Asian-Pacific Journal of Second and Foreign Language Education and web of science. One paper from the Czech Republic (2011) was issued in Procedia computer science, and after a gap of five years, another journal from the UK (2017) was published in emerald insight.

Moreover, two years later, one paper from China (2019) was published in IOP Conference Series: Materials Science and Engineering. There was no related paper in 2020, and one journal paper from Finland (2021) was published in research and practice in technology-enhanced learning. Furthermore, another paper was issued in Indonesia's journal of Studies in English Language and Education in 2021. In 2022, one article from Turkey was distributed in the Turkish Online Journal of Distance Education-TOJDE, and another journal paper from Spain was published in Contemporary Educational Technology. Therefore, it is worth conducting digital support for AI and non-AI technologies for writing skills in Thailand.

4.2 Types of AI and Technology Devices

The functionality of AI and technology devices could be effective for English academic writing in higher education since students from higher education need to do writing for their projects, journals, and publications. According to the result of this study, 11 papers are adopting AI and technology devices in English writing tasks. Starting from the study of Klimova (2011), this study applied online e-learning and wiki for academic writing to produce a Wikipedia text. The paper of Mcculloch (2017) applied AWE to evaluate academic writing practices, and the paper from Su, Miao, Liu & Man (2019) also utilized AWE to evaluate English writing. Additionally, the article from Talebinamvar & Zarrabi (2022) used AWE to cluster students' writing behaviors with web-based, based on argumentative writing.

Web-based mobile application Edmodo used in blended learning by Hosseinpour, Biria, Reza & Rezvani (2019) is another platform for practicing English academic writing. Rosyada & Sundari (2021) applied the google classroom application for the academic writing course. Similarly, Chong (2021) used google Forms to test students' prior knowledge of IELTS writing. Lopez's (2021) study employed online-related writing exercises to support students writing. The Facebook group also applied to support the learning process of students' academic writing, which was used by Saqr, Peeters,

& Viberg (2021), and Martinez (2022). A study from Taskiran &Goksel (2022) also employed the Facebook group as a learning process using write and improve the software.

4.3 Application Domains

The application domains of this study are defined by reviewing the genre of related eleven papers and perceiving which kinds of writing types are utilized with AI and non-AI technology devices in academic English of higher education. The analysis result identifies that there are argumentative essay writing types solely from two studies. One study employs an argumentative essay and an authentic Wikipedia article. On the other hand, two studies exploited research papers, argumentative essay writing, and a conference paper, as well as argumentative writing. Other domains in genre writing type ofAcademic writing applied through the discussions for both writing and oral presentation are done by one paper, and the main focus of the essay writing task is also found in one journal. Furthermore, IELTSwriting, cause and effect essay writing, descriptive writing tasks, and journal paper are utilized by another four journals correspondingly. Thus, there are 10 genres of academic writing from the finding of this study, such as argumentative essay writing, the essay writing task, authentic article for Wikipedia, IELTS writing, research paper, cause and effect essay writing, conference paper, descriptive writing tasks, academic writing, and journal paper.

4.4 Learning Strategies

Learning strategies in this part tend to emphasize the technology used for accessing or measuring students' writing. Firstly, the usage of the wiki for accessing academic writing in supporting writing and avoiding plagiarism is found in the study (Klimova, 2011). By studying the usage of AWE with learning strategy along web-based, a study from Talebinamvar & Zarrabi (2022) used keystroke logging with student cluster and writing quality to realize students' pausing behaviors in their writing and how they respond. Another study by Saqr, Peeters, & Viberg (2021) applied the ENA web tool to analyze the self-regulated learning tactics of students in their writing to observe how students develop their essential skills in academic writing. A study from Chong (2021) utilized an online multiple-choice quiz for preworkshop to test students' prior knowledge in IELTS writing and post-workshop to test students' knowledge again. The application of the google classroom platform can facilitate students' academic writing (Rosyada & Sundari, 2022).

Moreover, blended learning through the Edmodo mobile application is also one strategy for accessing students' writing (Hosseinpour, Biria, & Ehsan, 2019). The automated feedback system for writing and improving the software to measure students' writing (Taskiran & Goksel, 2022) and Facebook group for accessing writings and discussing among peers is also effective strategy in academic writing (Lirola, 2022). These results might be conveyed that blended learning through the Edmodo mobile application could be applied with AI-based writing tools.

4.5 Research Methods

The research methods in this paper refer to the method from 11 related papers exploring the utilization of AI and technology devices in Academic English writing in higher education. Among the 11 papers, 3applied the qualitative method in 2017, 2021, and 2022. Experimental design methods are found in two-journal papers in 2019 and 2022, and quasi-experimental studies are issued from two papers in 2019 and2022. Exploring the potential benefit of ICT as a tool for students' formal written English skills is foundin one article in 2011, and another method of analyzing and summarizing students' academic writing inthe genre of argumentative essays is explored in one paper in 2021. Besides, one study which applied explanatory sequential research design was founded in 2021, and a case study method was used in onejournal in 2021. That is to say. The experimental research design could be a transparent methodology for conducting educational research in AI and non-AI technologies in writing skills.

4.6 Results from Research Issues

After analyzing the related 11 papers, the outcomes from research issues of AI and technology-enabled writing are gathered. The consequences have four aspects: cognition to ascertain students' knowledge from learning; affection to notice participants' feelings about learning; psychomotor to distinguish professional skills that students acquire from writings; and, finally, causal analysis to identify the relationships or effectiveness in AI-enabled writing. For the cognition aspect, AI & technology-enabled writing can not only practice new academic writing and recognize the usefulness and necessity of the formal writing aspects but also can promote reading skills that students can learn from other writing posts used in the Facebook group, receive task achievement, coherence, and cohesion, lexical resource, grammatical range, and accuracy. In addition, students acquire metacognitive and factual knowledge, which can raise their confidence in expressing one's perspectives along with the nature of the scholarly writing process.

In the aspect of affection part to realize feelings of participants about learning, students can reflect on weaknesses and strengths from their writing performance, raise confidence in writing, promote social competencies in communication &cooperation from Facebook's discussion, and have positive attitudes towards learning English motivation, and engagement in online learning activities. Furthermore, lessons were more accessible, and technology usage and writing anxiety could also be controlled while dealing with academic writing standard pressure.

Linking to the psychomotor aspect, which distinguishes professional skills that students acquire from writing, it was found that the acquisition of writing skills can support the fields of information, finance, and tourism management. For the last aspect of Causal analysis in this paper that identifies the relationships or effectiveness in AI and non-AI technology-enabled writing, software feedbacks help learners to be better writers and get high-quality learning materials. Furthermore, an AI evaluation system can better observe students' learning processes and characteristics and formulate a more detailed analysis of learning conditions and feedback opinions. The process can also control and evaluate academic writing skills, which promote English writing achievement and enhance the writer's motivation and self-esteem.

5. Promising using Digital-supported English Writing Skills in Higher education in Thailand

This study conveyed a meta-review to analyze digital support as AI and non-AI technology-enabled writing in academic English of higher education from the published academic journals from 2011 to 2022. It was found that many studies testified how useful are AI and non-AI technology in academic English writing for participants' performance and improving writing. Most studies mentioned the prospective usage of AI and non-AI technology to support English academic writing and social competencies. Due to the rapid development of technology, the role of academic English writing with AI and non-AI technology tools is becoming more important in higher education. Since writing in higher education is quite critical, AI and non-AI Technology tools include supporting and knowledge-building parts of students' writing. Amazingly, based on the results analysis of this study, there is no study about digital game-based learning or gamification that supports higher education academic English writing to build students' knowledge and confidence in improving English writing.

On the other hand, the studies seldomly describe how academic English writing and the usage of AI andnon-AI technology can support the professional life of students in their future careers. Most studies focus on how students develop their writing skills and perceptions of using AI and non- AI technology-enabled writing. Therefore, it is worth investigating the potential and possibility of integrating AI and non-AI technologies to assist the academic writing of university students. From the above concerns, promising digital support for academic writing for Thai university students in the future study are listed as follows:

(1) Linking with higher education, which focuses on the university level of Thailand in English-writing skills, the sector of AI could not be ignored in applying or improving English writing. Lamjuanjit, Prachannant, & Jarat (2022) presented how AI's benefits in English writing can be

effective from the pedagogy approach. Therefore, it plays a decisive role in language learning by scholars based on the Thailand context. Thus, this paper would like to propose the contribution from some learning strategies and AI features of eleven reviewed papers that enable the writing skills of Thai university students, especially in undergraduate programs. Among the results, the google classroom platform can facilitate students' academic writing. Blended learning through Edmodo mobile application for accessing students' writing, Facebook group for accessing writings and discussing among peers, and measuring students' writing through automated feedback system from write and improve software could be applied in Thai context to enable students' writing.

(2) The Edmodo application in both mobile and computer-based versions could be applied to access students' writing and provide feedback to the writer from teachers and peers in both regular and blended classes.

(3) With the challenges of automated writing evaluation (AWE) to provide feedback on students' writing using natural language processing (NLP) technology, the current AI tool about natural language processing (NLP), as suggested by Wambsganss et al.'s (2020) study can be diffused to Thai university students in future language education of Thailand, especially for effective writing of students. It has served as a writing tool, including various features such as grammar and spelling suggestions and general feedback on specific aspects of the text (e.g., readability, persuasiveness of arguments, degree of formality, consistency).

This paper presents educational research on how digital support as AI and non-AI-based technologies could assist university students in English writing skills that can link to the Thai university context. Consequently, this will bring the practical usage of AI and technology features to enable students' English writing skills in Thailand's university education.

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Behind-the-Scenes: Challenges to Integrate Google Classroom in Teaching and Learning

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Abstract: Due to the outbreak of the COVID-19 pandemic, the Malaysian government has announced Movement Control Order (MCO) for the safety of the nation. Based on the latest data from UNESCO (2020), this measure has impacted over 7.9 million of learners in Malaysia. Subsequently, teachers in Malaysia are facing challenges to continue providing quality education to students due to the pandemic. Google Classroom was introduced after the termination of Frog VLE in Malaysia. However, the researcher found that implementing Google Classroom via online teaching and learning is ineffective compared to the face-to-face method. Hence, this study aimed to explore why Malaysian teachers face challenges in teaching and learning. The study employed a qualitative study using a semi-structured interview. The participants of this study were five teachers from different secondary schools in Selangor, Malaysia. Purposive sampling was adopted in this study with two criteria. The first criterion is that participants need to have experience in using Google Classroom in teaching and learning regardless of any subjects' while the second is that participants need at least five years of teaching experience in secondary school. As a result, a total of four themes were categorised. This research finding would offer insights to educational stakeholders and school administrators to improve the integration of Google Classroom in teaching and learning. Recommendations were generalisability and suggestions to the future researcher to explore ways to overcome the challenges faced by secondary school teachers.

Keywords: Challenges, Google classroom, challenges, teaching and learning

1. Introduction

In response to the outbreak of COVID-19 pandemic, the Malaysian government has announced Movement Control Order (MCO) (Prime Minister Office of Malaysia, 2020) for the safety of the nation. The pandemic has cost the country in every way and not forgetting the education system of the country. Schools have been closed down to ensure the safety of the students and the teachers. The closures of educational institutions have affected over 1.5 billion or approximately 91% of the learner population worldwide (UNESCO, 2020). Based on the latest data from UNESCO (2020), this measure has impacted over 7.9 million of learners in Malaysia. Subsequently, teachers in Malaysia are facing challenges to continue providing quality education to students due to the pandemic. The government has encouraged teachers to use Google Classroom to cope with the current situation, as it was officially announced as the main online teaching and learning platform after the termination of Frog VLE (Ministry of Education, 2019). However, we found that the implementation of Google Classroom via online teaching and learning is not that effective compared to the face-to-face method. Just accessing Google Classroom itself is a problem: Users are bombarded with the challenge of no strong Internet connection and limited WIFI usage (Nur et al., 2019), and no definite strategies are available yet for implementing and using Google Classroom (Hapini et al., 2019), high rates of plagiarism in contents created and uploaded (Bhat et al., 2018), and no real, actual hands-on activities can be made available during lessons (Tamin & Mohamad, 2020). Hence, the presence of these problems must be addressed as they may affect the classroom teaching and learning process. As Tamin and Mohamad (2020) mentioned, Google Classroom integration in teaching and learning as a medium of learning needs to be improved. Thus, there is a need to answer the research question of why Malaysian teachers face challenges to integrate Google Classroom into teaching and learning.

2. Literature Review

2.1 Google Classroom

Google Classroom is one of the Google Apps for Education (GAFE) used by most teachers and students in education because it is user-friendly (Azhar and Nayab, 2018). This application can be downloaded for free. Besides, other Google applications such as Gmail, Google Drive, and many more can also be integrated into Google Classroom (Noornadiah et al., 2022). According to Jeya and Brandforrd (2019), this application provides a platform for communicating with students and teachers to post announcements and evaluate students' assignments. First, teachers need to create a Google Classroom for any subjects comprising all students to be in the class. Then, teachers can post the announcements in the classroom, while students will get the notifications on their emails or any other devices that they installed Google Classroom (Bhat et al., 2018).

Besides manually inviting students to Google Classroom, teachers can send the link to students to join by themselves (Zakaria et al., 2021). This could help reduce teachers' workload, especially when they are many students. In terms of communication, teachers or students can communicate in the announcement's comment box. Evaluating students' assignments is also one of the strengths of Google Classroom (Kumar et al., 2020). When students tune in their assignments in Google Classroom, teachers can mark and provide feedback instantly to the students. Therefore, using Google Classroom is timesaving and eco-friendly (Zakaria et al., 2021). This is because teachers and students are doing their work online, and no paper is required throughout the process.

2.2 Challenges to Integrate Google Classroom in Teaching and Learning

There are many challenges of Google Classroom in teaching and learning, such as lack of ICT readiness among the teachers. In this context, researchers want to discuss why Malaysian teachers face challenges to integrate Google Classroom in teaching and learning. According to Wan et al. (2020), teachers rarely implement online teaching and learning in Malaysia. Hence, using Google Classroom is not practised in the classroom setting. This can be supported by Zakaria et al. (2021), who indicated that teachers and students find it difficult to use Google Classroom, especially at the initial level. In contrast, Tamin and Mohamad (2020) showed that students might find it easier to do assignments in Google Classroom because they can browse the information from other web-based platforms.

Besides, emergency remote teaching has been implemented due to the COVID-19 pandemic. The sudden switch from face-to-face teaching to online learning platforms leaves teachers with no clue about the next step. Therefore, many teachers were not prepared for online teaching and learning. Meanwhile, the research paper by Arumugam et al. (2021) indicated that teachers felt unenthusiastic in online teaching and learning compared to the face-to-face teaching method. This is because teachers encountered difficulties in preparing online materials for Google Classroom. According to Izhar et al. (2021), teachers found it hard to convert the hardcopy materials to softcopies and share them on online platforms due to the lack of ICT knowledge and skills. Teachers who lack of ICT knowledge and skills will need a longer time to prepare the materials. Hence, some teachers' normal lives were disrupted during online teaching due to long working hours (Arumugam et al., 2021).

Several studies conducted in Malaysia showed that teachers at all levels had increased workload during the pandemic (Kamal et al., 2020; Zakaria et al., 2021). According to Kamal et al. (2020), live classroom requires teachers to put a lot of effort into preparing their online lessons. Zakaria et al. (2021) indicated that teachers had to allocate much time to familiarise themselves with the features of Google Classroom. Besides, teachers also need to spend more time guiding the students to discuss the questions and answers with them (Zakaria et al., 2021). For example, teachers will use WhatsApp and Telegram to contact the students or provide feedback to students. Besides, learners also have trouble assessing Google Classroom at the initial stage (Zakaria et al., 2020). Hence, teachers and students need to be well prepared and familiarise themselves with the features of Google Classroom, and other Google applications such as Google Slides for teaching purposes (Lee et al., 2021; Zakaria et al., 2020).

Meanwhile, teachers also face challenges integrating Google Classroom in teaching and learning due to the lack of experience in managing the students via online. According to Yeap et al. (2021), online teaching requires certain skills, such as the requirements and materials that are not usually found at home. For example, teachers need to have a proper camera, scanner, and headphones. According to Yusoff and Marzaini (2021), students' participation is one of the barriers to integrate Google Classroom into teaching and learning. For example, students rarely complete the homework teachers send through Google Classroom. This is because students have negative attitudes towards using Google Classroom (Shelvam et al., 2021). This can be explained using Technology Acceptance Model (TAM) (Davis, 1989). According to the TAM acceptance model, there are two main variables: perceived usefulness and ease of use. Perceived usefulness is defined as "an individual who believes in the particular system will help to enhance the work efficiency in job performance". When individuals have positive attitudes toward using the system, they will have the intention to use.

3. Research Methods

The study employed a qualitative study using a semi-structured interview. A semi-structured interview was conducted because the collected data was mainly based on the respondents' personal experiences, perceptions, attitudes, and beliefs about the related topic (DeJonckheere & Vaughn, 2019). Purposive sampling was used to recruit the samples from this study. Besides, researchers also set a few criteria to recruit participants to participate in this study to ensure the data collected suits the research question. The first criterion is that participants need to have experience in using Google Classroom in teaching and learning regardless of any subjects' while the second is that participants need at least five years of teaching experience in secondary school.

Before data collection, researchers had been granted permission from the Ministry of Education Malaysia, state officers of education, and the researchers' affiliation Scientific and Ethical Review Committee to conduct research. The purpose of the study was explained in the consent forms and formal letters for the principals and the secondary school teachers involved. The Personal Data Protection Act 2010 form was also given to participants to keep their information confidential. Consequently, the respondents of this study were five teachers from Selangor.

Researchers constructed interview questions, and probes were used throughout the semistructured interview to elicit further in-depth information (Majid et al., 2017). There were four main interview questions:

- When did you start using Google Classroom for teaching?
- How do you find it when you first used the Google Classroom?
- Do you find it challenging while using Google Classroom in teaching and learning? (If yes, why? If no, why?)
- Why do you think integrating Google Classroom in teaching and learning is a challenge for you?

The researchers followed the steps suggested by Leavy (2017) to analyse the data: (1) Data preparation and eneralizati, (2) initial immersion, (3) coding, (4) eneralizati and theming, and (5) interpretation. Firstly, the researchers transcribed the data according to the interview recordings. Next, transcripts were read and reread to develop the initial ideas of the data to identify the potential themes. Thirdly, researchers had to segment the text from the transcript into categories using the terms. The coding process was done by using computer-assisted software (ATLAS.ti). The codes were then eneralizat, and themes were emerged from the data. Finally, the data were interpreted and discussed as the findings of the study. The interviews were audio recorded after receiving participants' consent. Field notes were taken for all interview sessions. A token of appreciation was also given to each respondent after the interview.

4. Findings

4.1 Demographic Information

The demographic information collected from the respondents includes gender, age groups, years of teaching experience and whether they had attended ICT training before.

Table 1. *Gender of respondents*

Gender	Frequency (*f*)	Percent (%)
Male	1	20.0
Female	4	80.0
Total	5	100.0

Table 1 shows the gender of respondents in the study, one (20.0%) male and four (80.0%) females. Therefore, the majority that participated in the interview were females.

Table 2. *Age groups of respondents*

Age group	Frequency (*f*)	Percent (%)
25 – 35	3	60.0
36 – 45	1	20.0
46 – 55	0	0.0
56 and above	1	20.0
Total	5	100.0

Table 2 shows that three (60.0%) of the respondents were between 25 to 35 years old, one (20.0%) was between 36 to 45 years old, and one (20.0%) was above 56 years old. Therefore, most respondents that participated in this study were between 25 to 35 years old.

Table 3. *Years of teaching experience in secondary school*

g experience (years)	Frequency *(f)*	Percent (%)
1 – 5	1	20.0
6 – 10	1	20.0
11 -15	2	40.0
16 years and above	1	20.0
Total	5	100.0

Table 3 shows that there is only one (20.0%) respondent respectively between 1 to 5 years, 6 to 10 years, and above 16 years of working experience. Two (40%) of the respondents have working experience of 11 to 15 years in secondary school.

Table 4. *Number of respondents who attended training*

Attended ICT training	Frequency (*f*)	Percent (%)
Yes	4	80.0
No	1	20.0
Total	5	100.0

Table 4 shows four (80.0%) respondents attended ICT training before, while one (20.0%) of the respondents did not attend any ICT training before. Hence, the majority of the respondents have experience attending ICT training before the implementation of Google Classroom.

4.2 Why Malaysian Teachers Face Challenges to Integrate Google Classroom into Teaching and Learning

The objective is to explore why Malaysian teachers face challenges to integrate Google Classroom into teaching and learning. Four themes and six categories emerged from the interview sessions conducted. The themes and categories are illustrated in Table 5.

Table 5. *Themes and categories*

Themes	Categories
Students' attitude problems	• Students do not submit their homework • Less participation of students
Insufficient ICT training	• Lack of ICT awareness and training
Poor network connection	• Problem connecting to Google Classroom
Increase in workload	• Prepare online materials • Spend time guiding students

4.2.1 Students' attitude problems

Students do not submit their homework

During the interview, all respondents indicated that the students were not submitting their homework, especially during online lessons:

> … students hardly tune in their homework or assignment. They give a lot of excuses and I really do not have so much time to go deeper to study, whether they are truly facing technical problems. (R4)

> … when students are not submitting their work, you have to try the offline method for them to submit their work. Then you try to give them work and ask them to just write them down and send it back to the school, and you collect it every month or in two weeks or something. Most of them did not send it to school. (R5)

Less participation of students

Some respondents also mentioned students are not participating in online learning, and some of them did not bother to check Google Classroom as well:

> … At the same time, they are very good at doing things that we don't do as adults… when you ask them to use their interest in education, for example, find the information about your favourite sport or singer … They won't be able to do it. (R5)

4.2.2 Insufficient ICT Training

Lack of ICT awareness and training

All respondents attended ICT training before; however, the training only covered the basics of ICT knowledge. Besides, the school also lacks ICT awareness, which causes the teachers to face challenges integrating Google Classroom in teaching. Among their views were:

> … the computer teachers and school administrators are not really motivated and not aware of the importance of being proficient in technology with education. (R5)

> … the school has only prepared us with 2 hours of brief in-house training. Everything was just shared at a very fast speed. It is quite hard for us. We can't understand at all sometimes. (R2).

Respondents explained their experiences in using Google Classroom. They find this Google Classroom challenging and confusing to use in the lesson. This is because they are unprepared for the sudden switch from face-to-face teaching to online teaching. The respondents also further explained that there were no clear instructions given on using the functions or features available in Google Classroom. This points out that the lack of ICT awareness and training caused the teachers to face challenges integrating Google Classroom in teaching.

4.2.3 Poor Network Connection

Problem connecting to Google Classroom
During the interviews, most respondents mentioned that connectivity is one of the reasons why Google Classroom is challenging for them.

> … even we teachers have the problem with internet accessibility. And a few of them doesn't even have an Internet connection and doesn't even have a modern mobile phone. I mean that the old mobile phones are not really suitable for them to browse Google Classroom. (R5)

However, respondent 4 added the viewpoint from the student's perspective:

> … I feel quite lucky because I have changed my WIFI. I am using unifi, and the connection is very good and there is no laggy problem for me. However, I found out from other teachers that many students couldn't access their WIFI and couldn't download their homework. Because some of the families are sharing devices, therefore there is insufficient data for them to upload homework in Google Classroom. (R4)

Therefore, the poor network connection is one of the reasons why teachers feel it is challenging to integrate Google Classroom into teaching and learning.

4.2.4 Increase in Workload

Prepare online materials
During the interview, almost all teachers mentioned the increase of workload because they need to spend time preparing online materials for the subjects they are teaching:

> I think Google Classroom is challenging for me because this is a new system and I am not trained in this before, except Frog VL… Malaysia has not been using online teaching before, and there was very less material and no eBooks at that time. … So, I have to learn from Youtube by myself. (R4)

> I spent a lot of time preparing online resources. For example, I need to cover the chapter about Group 17 elements…For this chapter, I used for almost 3 to 4 days to finish my PowerPoint and find videos for the experiments for students to see. I also need to include some notes for the teachers like "play the video from 1 minute to 2 minutes". Therefore, a lot of time was required to prepare the materials. (R3)

Spend time in guiding students
Another reason why Malaysian teachers face challenges when integrating Google Classroom into their teaching and learning is because they need to spend time guiding students, especially teaching students how to use Google Classroom. According to the respondents' views, most students do not know how to use the features of Google Classroom. During the interviews, the respondents commented:

> … students are also not used to it. I need to get used to Google Classroom itself, and at the same time, I need to teach them. Because when the students are using it, I also need to guide them and need more time to teach as well. That's why it is quite challenging for me. (R1)

To summarise, respondent 1 indicated that spending time guiding students is also one of the reasons why she thinks Google Classroom is challenging for her. This is because teachers must finish the syllabus in time, and guiding students through demonstrating on the spot will take a lot of time. Therefore, these are why Google Classroom is challenging for teachers in teaching and learning.

5. Discussion and Conclusion

5.1 Discussion

Results of the analysis indicate that the respondents faced several challenges while integrating Google Classroom in teaching and learning. The researchers identified four overall themes that explore why Malaysian teachers face challenges to integrate Google Classroom into teaching and learning, namely: students' attitude problems, insufficient ICT training, poor network connection and increase in workload. The results are almost in line with the research paper by Zakaria et al. (2021), as presented in the literature review. Four themes were found in the challenges of Google Classroom: student engagement, effort expectancy, attitude and facilitating condition.

Google Classroom is an effective communication platform, and there are several benefits and challenges simultaneously. Based on the findings, students give excuses for not attending and submitting their homework. Teachers face challenges to integrate Google Classroom into teaching mainly because students have negative attitudes toward using Google Classroom. This is aligned with the TAM model (Davis, 1989); when students have negative attitudes towards using Google Classroom, it will affect their intention to use it. Even though students are experts in using other technology platforms, such as taking videos and uploading to YouTube, they have less concern about submitting homework or browsing information online.

Besides, some secondary school teachers find Google Classroom challenging because of insufficient ICT training and poor network connection. According to Arumugam et al. (2021), Google Classroom only works where there is internet accessibility. Therefore, some of the teachers are not able to access the webpage due to poor network connection or due to network coverage in their housing area. Based on the findings, teachers also indicated sufficient ICT training is needed for teachers and students. According to Zakaria et al. (2020), the school management team should provide training for teachers and students to eneralizat themselves with the features of Google Classroom.

An increase in workload is also one of the reasons why teachers indicated Google Classroom is challenging for them in teaching and learning. Teachers must prepare materials and exercises for the lessons during online teaching. According to Izhar et al. (2021), teachers find it challenging to convert hard copies to soft copies and upload them to online platforms. Therefore, the lack of technical knowledge and skills caused an increased workload for teachers. In line with a previous study by Zakaria et al. (2021), the current study findings indicate that teachers also spent time guiding students and educating students to be familiar with the Google Classroom system.

5.2 Limitations, Recommendations & Conclusion

The present study's findings would give the educational stakeholders a new insight into Malaysian teachers' perspectives of Google Classroom. When the administrators acknowledged the difficulties experienced by the teachers while integrating Google Classroom, they could work together to overcome the challenges.

The results of this study are only limited to the Selangor area in Malaysia. This limitation has restricted the eneralization of the findings to represent entire Malaysia. Thus, future studies can consider enlarging the sample size by including other states in Malaysia. Besides, this study is limited to why teachers face challenges integrating Google Classroom into teaching and learning. Thus, future researchers could expand this study by exploring how to improve the integration of Google Classroom in teaching and learning by Malaysian teachers to improve the educational system.

In this study, we discovered that the respondents encountered various challenges from themselves and the students. Based on the research findings, four themes emerged in response to the research question: students' attitude problems, insufficient ICT training, poor network connection and an increase in workload. Some of the recommendations can be considered for future researchers to explore the topic of Google Classroom further.

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Multimodal Learning during the COVID-19 Pandemic: Exploring Students' Preferences

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Abstract: This study explores students' preferences for the various online learning activities that leveraged digital learning tools. Quantitative and qualitative data were collected from 23 education major students who learned online during the COVID-19 pandemic. Students found the multimodal activities effective in making them stay focused, engaged and acquire new knowledge and skills at a deeper level.

Keywords: Multimodality, online learning, COVID-19 pandemic

1. Introduction

During the COVID-19 pandemic, educators worldwide were compelled to transform their teaching modality entirely online to ensure continuity in their lessons. Educators had to adapt quickly to redesign their instruction as students were prohibited from being on campus for face-to-face classes. The unexpected closure of universities in Malaysia on 18 March 2020 due to the national lockdown ended students' campus life. All students were instructed to return home, where they continued to attend lessons remotely. The prolonged campus shutdown afforded educators some time to create appropriate learning activities with multimodalities by considering how students learn best to achieve the course learning outcomes.

May (2022) surmised that multimodal learning involves using various fun media to engage the learner's brain. According to Ferguson (2021, para.1), multimodal learning "engages students with content using multiple modes, or mediums of communication". In other words, multimodal learning is teaching a concept through various methods — visual, auditory, reading, writing, and kinaeasthetic (Litonjua, 2020). Multimodality improves the teaching quality and enhances students' learning experience through the engagement of the aforesaid four methods. Multimodal learning creates a learning environment for students to be more engaged because they do not need to conform to a specific learning style that does not suit them (Lintonjua, 2020).

Given the aforesaid context, we, as the course instructors of a compulsory course (Educational Technology, FCE3401) had an unanticipated opportunity to explore our students' preferences for the various learning activities that leverage digital learning tools that they were familiar with as students.

2. Objective of the study

This study aims to explore students' preferences of various learning activities that they were exposed to when FCE3401 was conducted synchronously and asynchronously for 14 weeks of the semester.

3. Course descriptions

Educational Technology (FCE3401) aims to equip students with fundamental knowledge and skills in educational technology through a 2-hour lecture and a 3-hour practical session for 14 weeks. During the COVID-19 pandemic, we prepared a robust assortment of activities to target many modalities for the entire semester. In other words, supplement our content delivery with a variety of media. We prerecorded our lectures using the Loom app. The pre-recorded lectures and the corresponding PowerPoint slides were shared with the students weekly. Communications with students were mainly done through WhatsApp. Students could access the pre-recorded lectures weekly at their convenience. To ensure that students do so as scheduled, students had to participate in a weekly online quiz for each topic through a differentiated assessment system — PutraPacer. Participation in the online quiz was compulsory, but it was not graded. Learning materials such as PowerPoint slides, assignments and rubrics were uploaded to the Learning Management System — Putrablast one week before each lesson commenced. Practical sessions were conducted synchronously using GoogleMeet, where students were given hands-on experience to learn basic computer coding using Scratch. They also learned to use Canva to create an infographic poster, and lastly, they produced an Augmented Reality teaching tool using Metaverse.

4. Methods

4.1 Participants

A total of 29 Education major students enrolled in FCE3401 at the Faculty of Educational Studies, Universiti Putra Malaysia (UPM). Specifically, they were from the Bachelor of Education (Home Science) programme. They were invited to participate in an online survey at the end of the course. Twenty-three students responded to our invitation.

4.2 Instrumentation and data collection

Students responded to five items related to their preferences for online activities. The scales ranged from 1 (definitely not helpful) to 10 (definitely very helpful). Students were also asked to express their opinions on their choices on the rating scales. The items in the questionnaire were developed by the second author and were content validated by the first author of this paper.

5.0 Results and Findings

Figure 1 shows most students found the instructions and information we gave promptly every week through WhatsApp very helpful in keeping track of the weekly lectures and activities. The following two excerpts reflect the students' positive feelings:

> *Instruction in the WhatsApp group could help students with a poor internet connection to join the learning because it did not use up much internet bandwidth. Students also wouldn't be left behind and can refer back to the instruction on WhatsApp when needed (student #17)*

> *I rated this activity at 10 because all of the instructions given are easy to understand and easy for me to read again for few times if I need to (student #19)*

Figure 1: Instructions given through WhatsApp group.

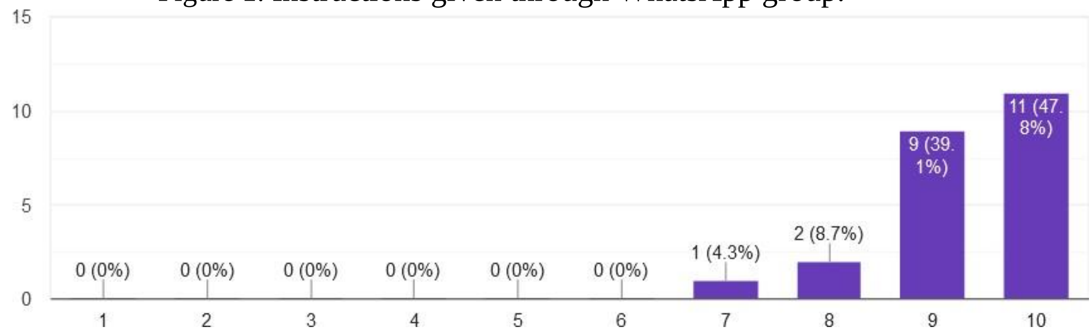


Figure 2 shows that students found the pre-recorded lectures helpful as accessing them conveniently at their own pace. They could also replay the video to understand the lessons better. Two students said the following:

> *I rated this activity at 8 because the recorded video of the lecture helped me to be disciplined on my timing and also help me to learn smoothly when the internet connection is good. The recorded video also helps to replay on the part that I'm don't really understand clearly. Overall, I am happy with all the recorded video given by Prof because it is so clear on the topic that we learn (student # 2)*

> *It's so convenient for me, I can watch the video many times if I cannot understand it. I can watch it when my internet access is stable (student #3)*

Figure 2: Video lectures on Loom (asynchronous learning)

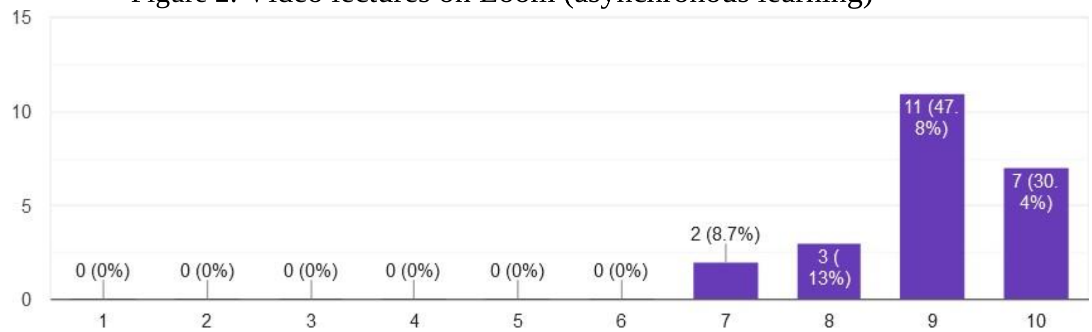


Figure 3 shows that most students found the weekly knowledge reinforcement activities to help fortify their understanding of each topic taught in the pre-recorded lecture. Students were able to gauge their knowledge of the weekly topics. They did not find the quiz a burden as the number of questions was adequate and related to the topic. One student expressed the following:

> I feel the exercise helped to enhance my understanding of the topic learned. The number of questions given was just right (student #15).

Figure 3: Knowledge reinforcement activities on PutraPacer (Pop Quiz)

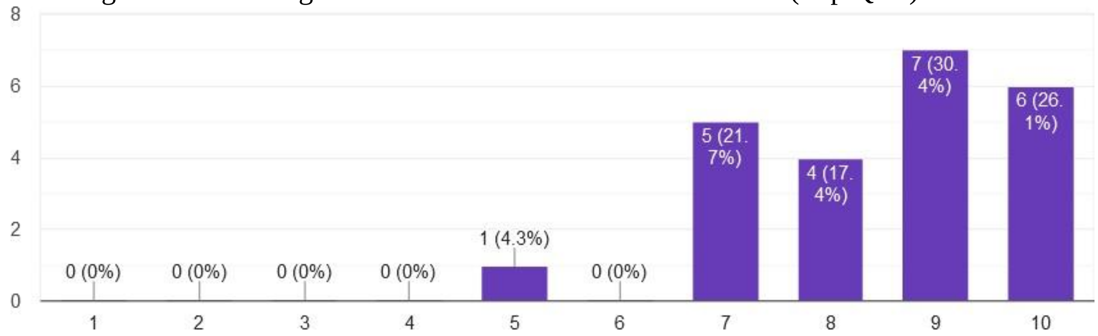
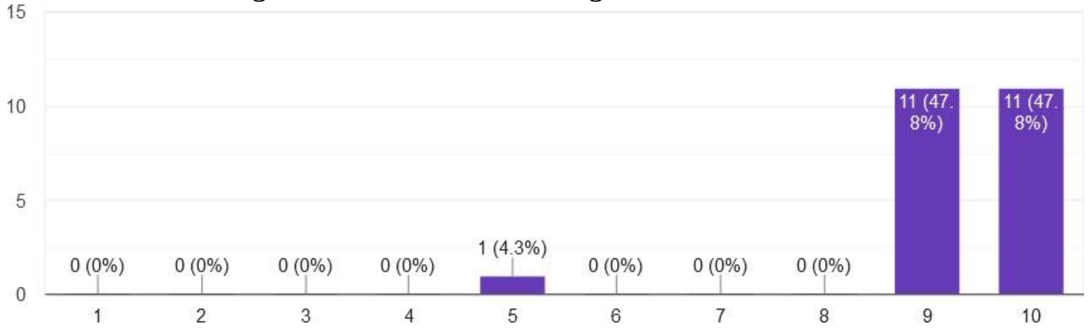


Figure 4 shows almost all students found Putrablast to be helpful in sharing relevant information about the course. Given that PutraBlast is the university's official learning management system, students were familiar with it. One student said:

> It's convenient to access it because students use it frequently to receive updates from lecturers (student #6)

Figure 4: Information sharing in PutraBlast



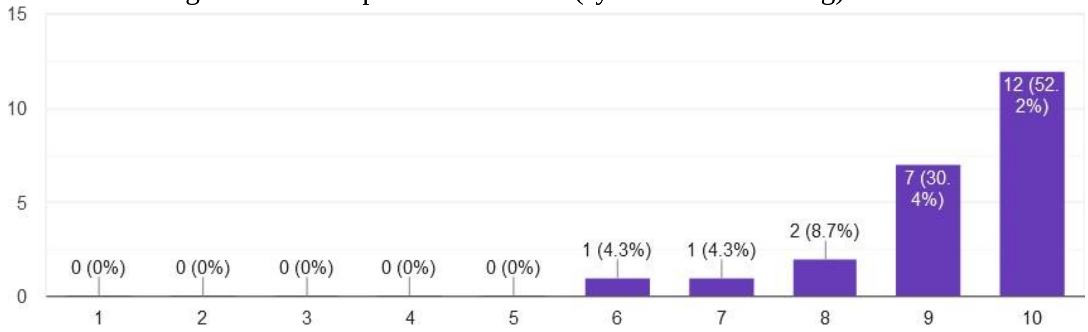
Most students found the online practical sessions through GoogleMeet beneficial (Figure 5). However, poor internet connection was a hindrance to learning. The following three excerpts captured the essence of the students' sentiments:

> *....online practical session is very good. We were able to ask our instructor questions on the spot if we didn't understand about the apps that we learned* (student #4).

> *The activity conducted in our online practical class was enjoyable, but at times the Internet access was poor. This caused me to miss some important part of the lesson. However, I was able to catch up because I recorded the session* (student #11).

> *Online practical sessions is convenient because we can learn wherever we are. However, synchronous learning may be hard for students with poor access of internet* (student #17).

Figure 5: Online practical sessions (synchronous learning)



6.0 Discussion and conclusion

This study explored students' preferences for various resources we utilised in our fully online course. We considered the resources appealing to our students as most found them helpful in their learning. Students were grateful to learn at their own pace (Wong & Md. Khambari, 2021). This is in congruence with Bdair's (2021) findings that online learning afforded flexibility, especially for students with easy access to various learning materials. Students also appreciated learning activities that required low bandwidth. Despite the positive sentiments, poor internet access was a problem for students.

To conclude, the multimodal activities we designed effectively made our students stay focused and engaged; and acquire new knowledge and skills at a deeper level. As we transition into the endemic stage where students return to campus, it is worth continuing with multimodal learning given the positive outcomes. Educators, therefore, must be proficient in implementing multimodal learning to create a holistic educational experience for their students.

For future studies, we recommend including more samples from other studies programmes to better represent the population at the Faculty of Educational Studies. A more comprehensive questionnaire should also be designed to capture more meaningful participant data.

7.0 Limitations of the Study

The data were collected through questionnaires comprising closed and opened ended questions. These data were based entirely on participants' honesty and how they perceived the digital learning tools utilised in the course. It must also be recognised that participants who participated in this study were 23 student teachers from only one programme of study at the Faculty of Educational Studies, UPM. Therefore, caution must be taken when generalising any findings for the entire population at the Faculty of Educational Studies, UPM.

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Teachers' Perceived Usefulness on the Utilization of Mobile-Learning Approach in Teaching High School Biology: A Case from the Philippines

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Abstract: Providing quality learning in science during the onset of the COVID-19 pandemic became one of the quandaries of most secondary schools in the Philippines, especially in remote areas. Likewise, high school teachers at Occidental Mindoro State College (OMSC) despite the prominence of technological learning platforms, have still resorted to the use of printed modules as primary learning modality due to the emergence of digital gap among the learners. Thus, the possibility of addressing the gap through the utilization of m-learning approach in teaching science on a distance-learning set-up was explored. Using a developed mobile-learning modular app (MoLMA) by the researcher, the approach was utilized in one of the Grade-7 Science classes of the institution. Following a descriptive-comparative mixed-method research design, the perceived usefulness of m-learning approach was gathered based on the pre-and post-perception responses of the teacher-users before and after the intervention. A focus group discussion was conducted therein after to gather an in-depth response. Results revealed high positive feedback in the utilization of m-learning before and after the intervention. Though both yielded positive responses, t-test results showed a difference between the areas of instructional delivery, enhancement of learning, and flexibility and convenience. Apart from promoting ubiquitous and personalized learning experience, results of FGD showed its cost- and time-efficiency in teaching biology subjects compared to the modular. Technologically speaking, results showed that m-learning is one of the most adaptive and accessible ways of utilizing technology-enabled learning in science at the onset of pandemic. It is recommended that the effectiveness of the approach in increasing students' academic performance shall be also tested.

Keywords: *Biology, mobile-learning approach, Mobile-learning Modular App, perceived usefulness,*

1. Introduction

The advent of technology in the current educational arena has provided a new horizon for its progress and development. It has shaped the perspective on how learning can be effectively delivered to the learners of the 21st century (Georgieva, Smrikarov, & Georgiev,2004). Though as widespread as it is, technology adoption and implementation have never been fully realized until the outbreak of the global coronavirus pandemic (Tria, 2020). In the onset of the pandemic, educators all over the world are expected to adopt certain pedagogical approaches and to employ effective solutions in extending learning even from a distance (Zhao, Wu, & Hua 2020) Apparently, as the country gear towards the adoption of online instruction and utilization of digital tools, several challenges and risks have emerged on the surface. This includes increasing technological disparity and decreasing equitable access to education between the fast-developing and slow-developing countries (Winthrop, 2020) Consequently, schools in the Philippines particularly in remote areas have difficulty in accessing stable internet connection. Evidently, not all teachers and students own a personal computer at home (Tria, 2020). Interestingly, however, based on APIS conducted by PSA in 2017, more people in the Philippines have access to a cell phone than to a toilet. It could be noted from the survey that of all the electronic gadgets, cellular phones are the most common household appliance in Filipino homes, followed by television. It was noted that 87% of the sample size have cellular phones. 91% of these families are in the higher-income households and 77.7% of these are low-income families who have at least one cellular phone per household (APIS, 2017). The declining price of mobile phones paved the way for more and more people, including those in remote areas, to own and to use mobile gadgets especially for learning (Keskin and Metcalf, 2011).

These reasons open the possibilities of using mobile phones as a tool for instructional delivery and learning, thus the term mobile-learning. Mobile learning is a form of learning dealing with acquiring and obtaining educational content and information, focused on acquiring cognitive skills, or enhancing learning motivation through digital means in personal pocket devices, including smartphones (Keskin & Metcalf, 2011). Evidently, m-learning became a fast-growing trend in educational settings as the development of mobile technologies has enabled learning on the move. As reviewed, most research pertaining to m-learning provide positive feedback on the enhancement of academic performance of the students all over the world. Not only that, m-learning perspectives promote ubiquitous learning, self-paced learning and lifelong learning (Sharples & Pea, 2014).

2. Review of Related Literature

Research on the use of m-learning in science education has started to gain attention since the year 2000 (Crompton et al.,2016). Several studies across the globe have revealed that the use of mobile phones in secondary science classrooms increased learner's conceptual understanding of the abstract concepts. Mobile technology use enhances students' interest/motivation (Zhai et al., 2018; Chang & Hwang, 2019) , positive reactions (Silva et al., 2018) and collaboration (Fu & Hwang, 2018) .
Ubiquitous experience provided by the approach also of great help particularly, in areas of Ecology and Biology, learning opportunities and experiences can be best shaped in relation to the learner's immediate environment in a specific location and time. (Sharples and Pea, 2014).

Though as promising as it is, as observed, this kind of approach was not yet fully adopted by the Department of Education. Though mandated by the constitution and by the recent curriculum changes, integration of m-learning especially in secondary schools in the Philippines has yet to be examined (Marcial, 2018). Aside from unavailability and technical factors, social factors like teacher resistance on its adoption can greatly affects its implementation. Perception of its importance can be attributed to the adoption of the approach (Aubusson et al., 2009; Cushing, 2011). "*Perceived usefulness is defined as 'the degree to which a person believes that using a particular system would enhance his or her job performan*ce" (Davis, 1989). In the context of e-learning, perceived usefulness is defined by Sun et al., (2008) as the perception of how user sees improvement in learning effects through the adoption of the system. Some educators in the Philippines feel that mobile devices cause too much distraction for learners, and or associate mobile device use during lectures with bad behavior (Ally, 2013). Constrains include instructors' lack of technical knowledge, perception on the use of technology and funds for professional development seminar in educational technology (Herro et al., 2013). And so, it is important for all users and stakeholders to understand the system of mobile learning and the necessary pedagogical skills and competencies it could offer (Marcial, 2018). It has been clearly proven that positive effects of m-learning in the academe based on several literatures, but its usefulness in the context of distance education is yet to be studied.

Hence, the researcher considered these practical gaps in science education of paramount importance to delve on. Thus, the researcher dwelled on the utilization of m-learning approach in teaching Grade-7 Biology to Junior High School students of OMSC using a developed mobile learning modular app (MoLMA). Specifically, the paper aimed to answer the following questions:What are the pre- and post-perceptions of JHS Science teachers on the use of mobile learning approach in distance education in terms of: Delivery of Instruction, Enhancement of Learning, Flexibility and Convenience and Willingness of Adoption?

- Is there a significant difference between the pre- and post-perception survey of teacher-users on the usefulness of mobile learning in distance education?
- What are the significant experiences of the teacher-users in utilizing m-learning approach in teaching science, particularly in Biology?

3. Methodology

The study followed a sequential explanatory mixed-method research design in which it involves the use of both quantitative (pre- and post-perceptions survey results) and qualitative (in-depth interviews and focus group discussion) data. an Input-Process-Output (IPO) model was used to describe the undertakings of the study. There are the three main processes that the study sequentially went through. The study started by having a casual conversation with the teachers in the target school regarding the availability of IMs for distance learning set-up. After realizing the absence of such, the researcher decided to review the DepEd Science Curriculum to select the topics to be modularized. The researcher decided to focus on Biology specifically Grade-7 Ecology. Also, reviews on the prominent e-modules and mobile learning apps were conducted prior to this research. The second phase focuses on the development of the app and the implementation of m-learning approach in one of the grade-7 Ecology classes of OMSC.

The application has two major features: first, the downloadable app that can be used and downloaded by mobile android users and can be run by the student's even offline; and second, the alternative learning management system interface added for the creation and uploading of supplemental teaching materials; delivery of instructions; monitoring processes for both teachers and administrators; and flexible communication among the users (see figure 1). The app is considered as hybrid. Hybrid applications are essentially online apps wrapped in a native app shell. Once downloaded from an app store and installed locally, the shell may connect to whatever capabilities the mobile platform gives through an embedded browser in the app content (Dimi, 2017). Prior to the implementation, a pre-perception survey was given to science teachers who digitally observed the process of implementation. After four weeks of implementation, a post-perception survey was given to the observers. This part covers the quantitative scope of the study particularly, descriptive-comparative design.

Meanwhile, the qualitative portion focused on gathering in-depth responses about the learning experience of the students on the perspective of teacher-observers during the implementation. An open-ended questionnaire consists of seven questions tackling the importance and usefulness of m-learning in the different aspects of the teaching-learning process patterned from the NCBTS, 7 domains of learning which is now PPST (DepEd No. 42 s. 2017). Five teacher-observers were invited to an online FGD through zoom. The results from the recording were transcribed, thematically analyzed, and coded using MAXQDA.

Figure 1. User Interface of the Developed App in Both Mobile and Wide-Screen Devices

4. Results

4.1 Demographic Profiles of Teacher Respondents

Part of the process of gathering the pre-perception of the respondents was the collection of their demographic profiles, which were used as a basis in the later results of the study. The demographics include the (1) years of teaching experience, (2) types of learning platforms used in science for distance learning, (3) Utilization of M-Learning Approach before the pandemic, and (4) the extent into which the approach was used.

Table 1. T*eachers' Demographic Profiles*

Description	Category	Frequency
1. Years of Teaching Experience	1 to 3 years	1
	4 to 6 years	1
	7 to 10 years	1
	11 years and above	2
2. Types of Learning Platform/s used in Science for Distance Learning	Printed Modules	4
	LMS	5
	E-materials	4
	Web/Internet	2
3. Utilization of M-learning approach before pandemic	Yes	5
	No	0
	Maybe	0
4. Extent of using mobile learning	Personal Level	5
	In class	0
	In a seminar/ training	0

n=5

Based on the results, most of the respondents are already proficient in their profession having years of experience from 4 to 10 years. Only once is a novice and two are already considered to be highly proficient having 11 years and above experience in teaching. Years of experience can be a contributory factor in technology adoption. According to the study of Andoh (2012) about Factors influencing teachers' adoption and integration of ICT, older teachers frequently use computer technology in the classrooms more than the younger teachers. The major reason could be that the older teachers having rich experience in teaching, classroom management and competent in the use of computers can easily integrate ICT into their teaching. However, further studies revealed that there is no direct relationship between teachers' teaching experience and experience in the use of ICT implying that teachers' ICT skills and successful implementation is complex and not a clear predictor of ICT integration (Granger et. al, 2002). In the second item, it could be noticed that most teachers do integrate the use of e-learning/digital and printed copy of their modules. All of them also use LMS as main learning platform in their teaching.

Meanwhile, the use of web/internet as primary platform for distance teaching is rarely practiced. This has something to do with weak or poor internet connection in the area. For the third and fourth items, it could be noted that most of them have already experience using the use of mobile devices in teaching however only on a personal level and not during the class discussion. Reasons on how it was personally used was not further explored. Yet, this suggested that all the respondents already recognized the potential use of mobile devices in learning.

4.2 M-Learning Usefulness as Perceived by Teacher-Users

To increase technology adoption and the effective use of its tools, faculty perceptions need to be considered. Positive perceptions among the users means acceptance of the approach. Teachers' perceptions greatly influence students' learning. Learners enjoy more the process of learning when teachers are enjoying the strategies being employed in their classes. With such, a pre- and post-perception survey was conducted to find out whether it changes their perception regarding the usefulness of m-learning approach.

Table 2. *Pre- and Post- Perception Results*

Area	Pre-p Average	Perception Interpretation	PostAverage	Perception Interpretation
Delivery of Instruction	4.36	Strongly Agree	4.36	Strongly Agree
Enhancement of Learning	4.12	Strongly Agree	4.76	Strongly Agree
Convenience and Flexibility	4.52	Strongly Agree	4.88	Strongly Agree
Willingness to adopt	4.68	Strongly Agree	4.76	Strongly Agree

Legend: *4.50-5.00-Strongly Agree; 3.50-4.49-Agree; 2.50-3.49-Neutral; 1.50-2.49-Disagre; 1.00-1.49- Strongly Disagree*

The table above prevails the pre- and post- perceived usefulness of m-learning. It can be noted that prior and after the implementation, the average of teachers' perceptions is both positive. Though both the pre- and post- surveys have positive interpretation, there was an increase in the mean rating of some of the areas of the pre-perception results. This includes the *enhancement of learning, convenience and flexibility and willingness to adopt.* Among these three, the Enhancement of Learning aspect has the highest mean rating increase This suggests that the m-learning approach introduced to the class, as observed, and evaluated by the teachers, enhanced the learning experiences of the students in science even from a distance. This supports the second assumption of m-learning where learning becomes more personalized. Students can learn at their own pace and style. This helps them acquire independence and responsibility for their own learning which leads to a strong ownership of learning (Leadbetter, 2005; O'Malley et. al, 2003; Kenny et. al, 2010).

Table 3. *Significant Difference Between Teachers' Pre- and Post-Perception*

	Test	Mean	Std	t-stat	one-tail t-crit	one-tail p-value	Interpretation
Respondents	Pre-	4.42	0.40	-2.56	2.13	0.031	Sig. Diff
	Post-	4.78	0.24				

To find out if there is really a significant difference between the pre- and post-perception responses of the respondents, a paired t-test was used. The table above shows the results of the aforesaid difference. The p-value of 0.031 is less than the set alpha level of 0.05 which leads to the rejection of the null hypothesis. Therefore, there is a significant difference between the pre- and post-perceptions of the teachers on the use of m-learning after the implementation. Further, the closed proximity between the mean results of the two tests leads to a negative t-stat= -2.555. Nevertheless, it is still higher than the t-crit= 2.132 which supports the rejection of the null hypothesis. Hence, this corresponds to the notion that after the intervention teachers' perception on the usefulness of m-learning becomes even more positive. This is a good start point to evaluate the readiness of the school in infusing such approach in their current set-up

4.3 Results of Mobile Learning Experience Through Focus Group Discussion

The table below shows the thematic analysis of the teachers' responses on the online focus group discussion conducted after the implementation. The table is divided into three columns namely: Theme, Aspects and an example quotation that came from exact words of the respondents. The observation on the use of m-learning were categorically divided on two its usefulness on the learners and it's on the side of the teachers. Additional observations were also added tackling the concerns and hindrances encountered by the teachers while implementing the approach.

Table 4. *Analysis of Teachers' Assessment on the M-learning Approach*

Theme	Aspects	Example Quotation
On the side of the students		
Improved learning achievements	Increased motivation and students' engagement with the subject	'They found the videos really engaging." "There are videos which can be played when the students have access to the internet"
	Highly Interactive	"Mobile app is colorful compared to a plain text making it more realistic and easier to understand unlike the modular approach where the pictures are printed in grayscale or dark-colored ink" "Students become more excited and motivated whenever they use the mobile app.."
	Organization of learning	"Students can see the objectives easily for their specific lesson and click on the desired content unlike the modules that they have turn the page back and forth."
Autonomy and Personalized Learning Experience	Students can monitor their success in learning	'After taking the quiz they can easily check whether they learned the lesson or not because of faster results" "It's easy to give feedback. So, they can easily check their mistakes and the output they haven't submitted yet."
Ubiquitous Learning Experience	Highly Accessible	"The app can be accessed even offline." "what's good about a mobile device compared to other gadgets is highly adaptable. You can download the apps and browse the file even offline."

		"They can easily check concepts by checking their phone. It is easy to bring anywhere"
Adaptability	The App is Suitable to the learners of 21st century	'Learner's today are visual learners; they prefer to watch video rather than reading text from a plain module" "If students could not really understand what is being said in the text, you can watch the video."
Communication	Students Can Reach out their concerns instantly to their teachers. Communication is vital in achieving success in distance education. In the transactional distance theory (TDT), Moore (2007) defines distance education in terms of responsiveness of an educational program to the learners rather than in terms of geographical separation of the teacher to the learners.	"They have the means to communicate easily with their teachers." "It's easy to give feedback through m-learning."
On the side of the teachers		
Efficient Tool for Assessment	Easy Checking of Quizzes, recording and monitoring of students 'performance which makes the grading more fluid and transparent. According to Uribe and Vaughan (2017), instant assessment is critical in distance education set-up due to the asynchronous nature of instructional delivery. An additional effort is required to confirm that students are ready to receive and respond to feedback properly.	"The app done the checking and recording for me.: "I can easily check their output and return it right away. So, it's easy to give feedback." "I can see (easily) if the students are improving, or the scores are getting higher"
Cost and Time Efficiency	The App in mobile is much Easier to operate and to master	"Teachers are not 100% ready for online classes due to unavailability and readiness of the printed modules" "The printing of modules (implemented by most DepEd Schools) is very costly and time

		consuming especially for colored module with so many pages." "The mobile makes it easier for teacher to transfer the modules with less work and money required."
Hindrances and Concerns		
Technical Issues	Freezing and glitching of the mobile devices	"Though minimal, glitching can also interrupt students' learning"
	Lack of internet	"Some areas do not have internet connection and worst have experienced power interruption"
Academic Dishonesty	Authenticity and reliability of students' response in assessments	"Still as of this moment we still lack a specific app that measures the student's academic honesty in answering the test" "Students can use the phone to search for the answers while taking the test" "It requires the presence of internet to check the student's activity on time."

5. Conclusion and Recommendation

Teachers prior to the implementation had already a positive perception regarding the usefulness of m-learning in teaching science from a distance. Yet, it became even more positive after the implementation especially in the enhancement that the approach provided in the learning process of the students. Moreover, a significant change on these perceptions (pre- and post-) were identified when tested statistically. These things are of vital consideration in technology-adoption in education (Ebardo, 2018). Based on their perspectives, m-learning helps in enhancing students' learning in science by providing autonomy and ubiquitous learning experience. M-learning also helps in facilitating faster communication between teachers and students and provide efficiency in assessing students' performance amidst distance. The approach was very suitable to the learners of the 21st century due to their learning styles and familiarity of the technology. These factors are the relevant aspects that one must consider on a distance education backed up by the transactional distance theory (TDT) of Moore (2007). theoretical framework created by Moore. Meanwhile, on the side of the teachers, m-learning is beneficial in decreasing the burden of administrative tasks making it more cost- and time-efficient for the educators. In the end, aside from technical factors, the authenticity of students' responses in the assessment on a distance-learning is still the main challenge that are yet to be solved. With continuous refinement and study, the m-learning has a potential to be a flexible and inclusive learning platform in science on a distance learning set-up.

Since the study is conducted during the earlier phase of the pandemic, health safety of the participants involved and ethical considerations like academic honesty limit the researcher to further investigate its effects on the academic performance of the students in science. Therefore, as the educational system slowly shifts back to the normal face-to-face set-up, it is recommended to implement the approach applying two-tailed analysis using two-group set-up. Moreover, Acceptability among the target users can also be gathered in the long run. In a larger scale, formal integration of m-learning approach in secondary science curriculum in the Philippines must be examined as it offers quality learning experience in delivering Biology lessons to the 21st century learners even from a distance or remote set-up. Its flexibility, accessibility, and ubiquity can also narrow the digital gap among the Filipino learners with diverse economic backgrounds. Future directions of this study will be of paramount importance for science educators to navigate through the intricacies of M-Learning as Philippines slowly reverts from distance to HyFlex to normal learning set-up.

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Exploring the Behavior Patterns of Students Accessing Online Learning Material in Online Course: A Case Study at Hung Vuong University

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Abstract: Understanding students' behavior in online courses may provide teachers with useful information to improve their educational design and provide insights for content and instructional designers to develop personalized learning support. This research uses cluster analysis to explore learners' interaction with online learning materials behavior in an online course at Hung Vuong University, Vietnam and identified three clusters (Less-engaged students, Moderately-engaged students, and Highly-engaged students) which evince different behavior patterns with regards to the time spent interacting with various resources. Based on the findings, several suggestions are also proposed for future research.

Keywords: students behavior, online courses, cluster analysis, behavior patterns

1. Introduction

In Vietnamese context, online learning or blended learning has been introduced for years (Maheshwari, 2021; Dinh & Nguyen, 2020; Van Anh & Nguyen, 2020); however, we still lack of the information on how students performs or interactive in the online course. It is well recognized that the interaction with online learning materials is one of the most commonly performed online learning activities (Li & Tsai, 2017). Teachers and students typically publish and create different kinds of online resources for learning, and such materials give different learning advantages. For example, lecture slides give an outline of teaching contents for students and facilitate students' note-taking (Worthington & Levasseur, 2015), students may review challenging concepts and prepare for examinations through video lectures (Hong, Pi, & Yang, 2018), while peers' assignments and messages posted in discussion forums are essential resources for self-reflection (Sun, Lin, Wu, Zhou, & Luo, 2018; Zheng, Cui, Li, & Huang, 2018). Students may demonstrate different levels of engagement and patterns of behavior when interacting with online learning materials for different purposes and based on different preferences (Cerezo, Sánchez Santillán, Paule Ruiz, & Núñez, 2016; Li & Tsai, 2017); these levels of engagement and patterns of behavior may, in turn, affect their learning performance (Cerezo et al., 2016; Lust, Elen, & Clarebout, 2013a).

Consequently, understanding how students interact with different types of learning materials and how their behavior in interacting with these materials affects their learning performance may provide teachers with useful information to improve their educational design and provide insights for content and instructional designers to develop personalized learning support. However, only using statistical methods is not enough to explore students' interaction with online learning material behavior. Cluster analysis (e.g., the K-means method) can be used to investigate the behavior cluster patterns of a group regarding various indicators (such as the frequency of a particular discussion behavior) (Huei Tse Hou, 2011). Thus, the use of clustering techniques on these behavior sets enables the potential cluster patterns of learners' different behaviors to be explored when interacting with online learning materials (Bakhshinategh, Zaiane, ElAtia, & Ipperciel, 2018; Huei Tse Hou, 2015; Huei Tse Hou & Li, 2014; H. T. Hou & Wu, 2011; Li & Tsai, 2017).

Hence, our study is focused on providing more in-depth perspectives and insightful information derived from students' interaction with online learning material behavior, for instance: their interaction with online learning material behavioral patterns that occurred during their learning process. Our research question is proposed as follow: What are the students' clusters of interacting with online learning material in an online class?

2. Literature Review

Analyzing students' behavior in interacting with online learning materials helped in identifying learners with poor performance (Li & Tsai, 2017; Zhang, Zou, Miao, Zhang, Hwang, & Zhu, 2019), and hence in providing improvement suggestions (Lerche & Kiel, 2018; Zhang, Zhang, Zou, & Huang, 2018; Zhang et al., 2019). Researchers have also pointed out that correlation analysis can help the instructor to determine the relevance between students' learning behavior and performance (Zhang et al., 2019), as well as assist in decision-making and improving teaching and learning processes (Zhang et al., 2019).

In addition to using statistical methods, several studies have used cluster analysis to classify students into distinct groups (Huei Tse Hou, 2015; Li & Tsai, 2017) and to investigate their learning performance (Perera, Kay, Koprinska, Yacef, & Zaïane, 2009). In recent research, Li and Tsai (2017) concluded that different behavior patterns were associated with students' motivation and learning performance. Cluster analysis (e.g., the K-means method) can be used to investigate the behavior cluster patterns of a group regarding various indicators (such as the frequency of an individual discussion behavior) (Huei Tse Hou, 2011). By applying cluster analysis, the potential cluster patterns of learners' various behaviors can be explored (Huei Tse Hou, 2012, 2015; Huei Tse Hou & Li, 2014; Li & Tsai, 2017) (for example, by analyzing the overall learning process of a group of students, questions can be raised: How many potential clusters of learners with similar behavioral traits are being formed? What are the characteristics of each cluster?). In other words, it provides an opportunity to discover meaningful data from learners individually (Perera et al., 2009).

This study applied the most frequently performed interacting learning material activities, as stated in the previous research (Cerezo et al., 2016; Li & Tsai, 2017; Su, Ding, & Lai, 2017) with a Learning Management System (LMS) applied. Therefore, seven activities were identified and selected: Page Hits on Questions, number of Answers Posted, number of Answers Revised, Page Hits on Lecture Slides, number of Comment Posted, number of Discussion Posted, and number of Discussion Edited.

3. Method

3.1 Research Design and Participants

This study aimed to examine the effects of online learning behavior on online learning regarding students' academic performance in a class with the use of an LMS. The participants were 38 university students (33 males and five females) enrolled in a course named INT326 English for Computer Science. The course was compulsory for all the students, and after passing the final examination, they were awarded three credits counting towards their graduation.

3.2 Experimental Procedure

The class took place on a weekly basis for the duration of 15 weeks; however our experiment only took 8 weeks of the whole class duration. Class time was the main point of interaction between teachers and participants. Each lecture took three hours and the course is purely online during the COVID-19 pandemic. During the first week of the experiment (week 1 of the semester), an introductory class was held in order to instruct students on how to interact with an LMS system named HVU LMS and access the course-related resources. Students were familiarized with the environment, compulsory class components, and evaluation processes.

Subsequently, from week 2 to week 8 of the experiment, students were taught 3 hours a week using the proposed online learning system as an environment for submitting assignments. The students were encouraged to use the learning system after class.

3.3 HVU Learning Management System

HVU LMS is an online learning environment, a Moodle-based eLearning platform developed at Hung Vuong University. In this system, students are able to generate questions and discuss with each other by asking, answering questions, and commenting through the provided functions. Instructors are also able to generate questions, share learning resources, and develop the effectiveness of class management. HVU LMS main interface offers multiple functions that can be used to promote online learning can be seen in Figure 1.

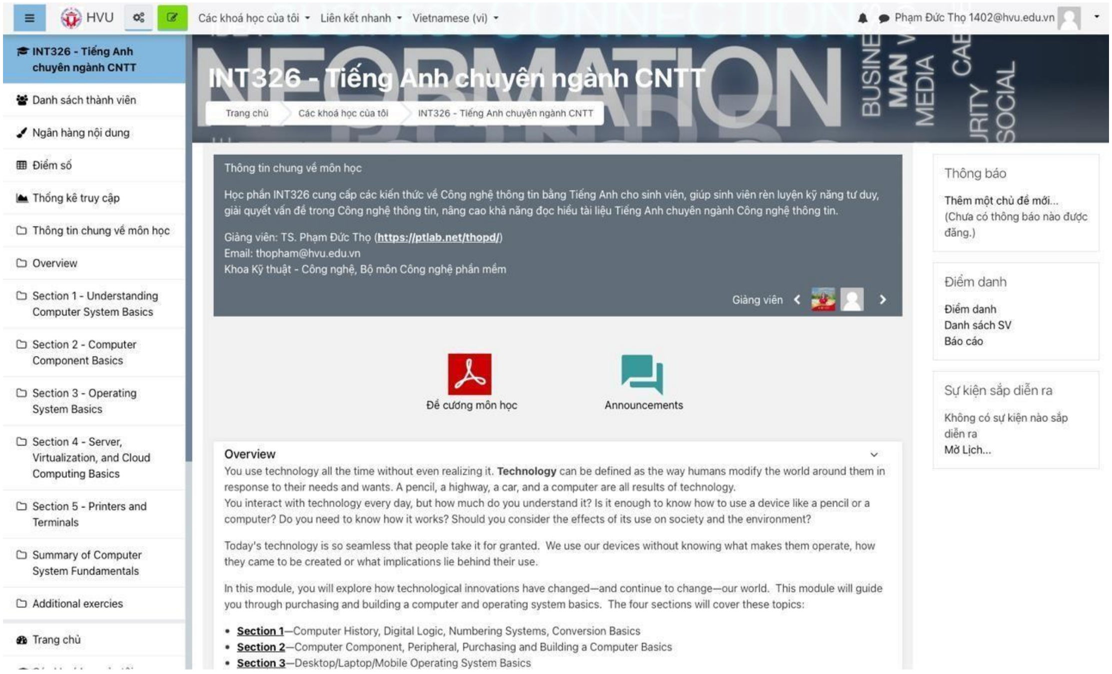

Figure 1. HVU LMS User Interface

3.4 Data Collection and Analysis

In this study, analyzed data were in the forms of log files, which contain the participants' interactions and all information needed on HVU LMS from a database powered by MySQL. The researcher collected data in a total of eight weeks. The number of questionings, comment, revision, and access to learning materials was calculated by simple SQL queries based on unique user IDs. The data were gathered from an HVU LMS database via phpMyAdmin; luckily, missing values were not found in the dataset. Afterward, they were exported into a CSV file for further transformation.

After completing the data cleaning process, the data were then carefully transformed into a sav file for SPSS analysis. Importantly, the student's behavior was extracted from log files individually by using SQL queries based on unique user IDs. To differentiate the participants into groups according to the similarities of their interaction with learning materials behavior (e.g., questioning, commenting, assignment completion, revision, and access to learning materials) that occurred during their computer programming learning progress on the proposed online learning system (i.e., HVU LMS), we extracted a total of seven variables for the analysis as listed in Table 1. A complete enumeration of these variables, along with their basic statistical properties, can be found in Table 2. All of the time-related variables are measured in the total number of occurrences. Despite the small size of our test group, Box Plots of our seven crucial variables still revealed numerous cases that were very distant from the IRQ region, as illustrated in Figure 3. Since these deviations could negatively project onto the clustering process, we decided to transform these variables to a scale of 1-3 in order to reduce the bias in the cluster analysis, following the methodology of Li and Tsai (2017). The 33.33% lowest, intermediate, and highest access times were allocated a value of 1, 2, and 3, respectively, indicating low, moderate, and high access times. In the following, we will refer to the transformed variables as $t^T_{QV}, t^T_A, t^T_R, t^T_L, t^T_C, t^T_{QP}, t^T_{QE}$. Further, we deployed k-means clustering among various subsets of variables as dimensions of the Euclidean space to search for learning behavior patterns. The number of clusters to consider was decided based on the size of the underlying dataset and the dendrogram resulting from its Hierarchical Agglomerative Clustering (HAC). We proceeded in our analysis with clusters that appeared to be consistent, balanced, and mutually distant.

Table 1. *Variables Extracted from HVU LMS*

#	Variable	Variable Description
1	t_{QV}	Page Hits on Questions
2	t_A	Answers Posted
3	t_R	Answers Revised
4	t_L	Page Hits on Lecture Slides
5	t_C	Comment Posted
6	t_{QP}	Discussion Posted
7	t_{QE}	Discussion Edited

Table 2. *Mean and Standard Deviation of Variables Extracted from HVU LMS*

#	Variable	Variable Description	Mean	SD
1	t_{QV}	Page Hits on Questions	619.42	607.41
2	t_A	Answers Posted	48.53	17.44
3	t_R	Answers Revised	34.79	49.37
4	t_L	Page Hits on Lecture Slides	63.76	35.19
5	t_C	Comment Posted	59.32	166.9
6	t_{QP}	Discussion Posted	4.08	2.78
7	t_{QE}	Discussion Edited	6.79	14.58

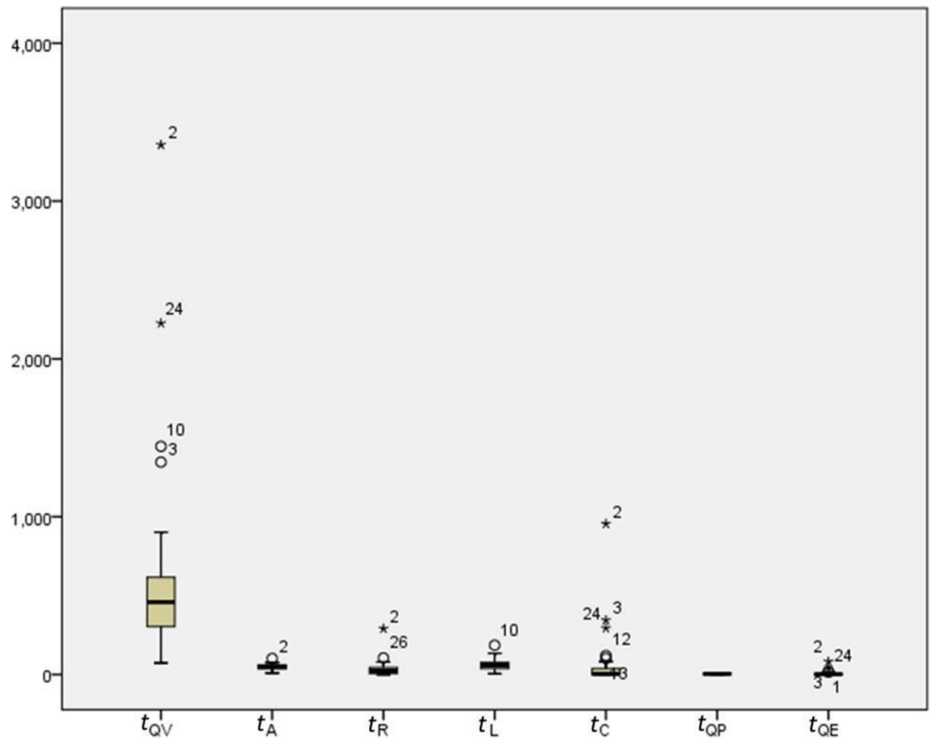

Figure 2: Boxplot of t_{QV}, t_A , t_R , t_L , t_C , t_{QP}, t_{QE}

After identifying the participants' similarities and clustering them into groups, the significant differences, in terms of their learning performance, among the generated clusters must be revealed statistically. Traditionally, a parametric analysis, such as one-way ANOVA, can be used to analyze data if the assumptions are met. The assumptions are as follows:

- Random independent samples
- Interval or ratio level of measurement
- Normal distribution
- No outliers
- Homogeneity of Variance
- A good amount of sample size

However, the data used in this experiment had not met the assumptions mentioned above. In this case, a non-parametric test can be used to analyze the data (Li & Tsai, 2017). Even though non-parametric tests do not have statistical power compared to parametric ones, they are more conservative. Consequently, this study implemented a Kruskal-Wallis test as the primary data analysis method. Furthermore, if a Kruskal-Wallis test demonstrates at least one significant difference among the clusters, a Mann-Whitney test will be conducted as a post hoc test (Li & Tsai, 2017; López, Valenzuela, Nussbaum, & Tsai, 2015). It should be noted that the significance level was set at $p = .05$.

4. Results and Discussions

To classify the students with similar interaction patterns into a homogeneous group, k-means cluster analysis was performed on the seven transformed variables t^T_{QV} , t^T_A, t^T_R, t^T_L, t^T_C, t^T_{QP} , t^T_{QE} . As shown in Table 3, three clusters were identified. These clusters evince differences in students' learning behavior patterns, and therefore we assigned them slightly suggestive names:

(1) Less-engaged students
(2) Moderately-engaged students
(3) Highly-engaged students

As shown in Table 3, from the variance on the average frequency of the seven main behaviors – View Question, Answer, Answer Revision, Learning, Comment, Generate Discussion, and Discussion Edit (t^T_{QV}, t^T_A, t^T_R, t^T_L, t^T_C, t^T_{QP}, t^T_{QE}), as exhibited by the three clusters of students, we learned that students' interaction with learning materials behavior patterns in the online class was distinctively different. The three clusters comprise 16,14, and 8 people, respectively, accounting for 42.11%, 36.84%, and 21.05% of the total students.

Table 3. *Cluster analysis of Interacting Online Learning Material behavior*

Indicators of cluster analysis	Clusters Less-engaged students (N=16, 42.11%)	Moderately-engaged students (N=14, 36.84%)	Highly-engaged students (N=8, 21.05%)	F
t_{QVT}	1.19	2.36	2.88	49.461***
t_{AT}	1.25	2.43	3.00	52.991***
t_{RT}	1.88	1.64	2.75	6.169**
t_{LT}	1.19	2.43	2.63	29.02***
t_{CT}	1.44	2.29	2.75	13.074***
t_{QPT}	1.19	2.21	2.88	39.003***
t_{QET}	1.50	1.79	3.00	15.122***

$^{**}p < 0.01$, $^{***}p < 0.001$

More than 20% of the students are centered in the Highly-engaged students Cluster (N = 8, 21.05%), and the average learning behavior frequency of their behaviors – View Question, Answer, Answer Revision, Learning, Comment, Generate Discussion, and Discussion Edit (t^T_{QV}, t^T_A, t^T_R, t^T_L, t^T_C, t^T_{QP}, t^T_{QE}) – was higher than that of the other two clusters. This suggests that 21.05% of the students learning this course exhibited behaviors with more action than the other two clusters. On the other hand, it is to say that more than 40% of the students learning this course exhibited behaviors with significant inactively than the other two clusters.

After classifying the students into homogeneous groups based on similarities in their course material viewing patterns, we performed the Kruskal–Wallis test in order to compare Less-engaged students, Moderately-engaged students, and Highly-engaged students with regards to the set of collected variables. The test outcome is depicted in Table 4. We observed a statistically significant difference in all the aspects measured.

Our result is aligned with the previous study conducted by Li and Tsai (2017), and provide evidence that Less-engaged students spent significantly less effort on most activities, namely t_{QV}, t_A, t_L, t_C, t_{QP}, when compared to Moderately-engaged students and Highly-engaged students. However, we cannot conclude the difference between Less-engaged students and Moderately-engaged students in the revising activities t_R, t_{QE}. On the other hand, our results identified a Highly-engaged students cluster, which consists of students with significantly more effort measured in all kinds of learning materials when compared to both the Less-engaged students and the Moderately-engaged students. Moreover, although we could not establish any relationship with regards to the average time spent on Learning and Commenting t_L, t_C between the Moderately-engaged students and the Highly- engaged students, our results reveal that students from both the Highly-engaged and the Moderately- engaged clusters spent a significantly longer time on average on Learning and Commenting access than the Less-engaged students.

Table 4: *Analysis of Online Learning Behavior*

Var	Less-engaged students (1)		Moderately-engaged students (2)		Highly-engaged students (3)		Kruskal–Wallis Test	Mann-Whitney U Test
	Mean	SD	Mean	SD	Mean	SD	p	
t_{QV}	278.81	91.09	565.79	124.42	1394.50	972.70	0.000***	2<3 2>1 3>1
t_A	33.31	8.94	53.64	8.21	70.00	14.22	0.000***	2<3 2>1 3>1
t_R	22.37	22.01	23.50	26.15	79.38	87.73	0.011*	2<3 3>1
t_L	37.19	17.98	74.21	16.55	98.63	46.08	0.000***	2>1 3>1
t_C	3.44	7.14	35.00	43.59	213.63	328.74	0.000***	2>1 3>1
t_{QP}	1.62	1.02	4.86	1.66	7.62	2.07	0.000***	2<3 2>1 3>1
t_{QE}	1.56	2.94	2.50	3.11	24.75	24.87	0.000***	2<3 3>1

*p < 0.05, **p < 0.01, ***p < 0.001

5. Conclusion and Future Works

5.1 Conclusion

In this research, we explored and revealed students' interaction patterns with regard to online resources based on students' different identified groups of interaction with online learning material behavior. Based on the information gathered, we attempted to answer our research question by identified three clusters (Less-engaged students, Moderately-engaged students, and Highly-engaged students) which evince different behavior patterns with regards to the time spent interacting with various resources, i.e. t_{QV}, t_A, t_R, t_L, t_C, t_{QP}, t_{QE}. We detected one cluster of students (Highly-engaged students) that dominated the other two (Less-engaged students, Moderately-engaged students) in all leading variables. This result aligned with a previous study by Li and Tsai (2017), who identified a single cluster on the lower-access end ("low-use-students") and two clusters on the higher end ("slide-intensive-students" and "consistent-use-students"). However, we cannot conclude the difference between the Less-engaged students and Moderately-engaged students in the revising activities t_R , t_{QE}. Moreover, although we could not establish any relationship with regards to the average time spent on Learning and Commenting t_L, t_C by the Moderately-engaged students and the Highly-engaged students, our results indicate that students from both the Highly-engaged and the Moderately-engaged clusters spent significantly more time on average Learning and Commenting than the Less-engaged students.

5.2 Future works

Based on the findings, this study provides several suggestions for future research:

Future works can deep investigate the content analysis of comments and discussions to students' engagement and students' behavior. It is also interesting to investigate the effect of the automated reply feature of HVU LMS on students' engagement and students' behavior.

For the future development of HVU LMS, we suggest embedding the automatic analysis and instant feedback mechanisms along with early-detection behavior groups into the learning system as a future trend (Huei Tse Hou, Chang, & Sung, 2010). Integrating real-time computing with earlydetection sequential patterns of learning behavior in HVU LMS may be enhanced by developing mechanisms that provide real-time learning feedback as scaffolding. This approach not only promptly provides teachers with diagnoses of student misconceptions or bottlenecks in learning as important reference information but also offers corresponding real-time guidance regarding the behavior patterns of specific incorrect manipulations. Such an automatic feedback design may optimize the learning process, allowing continuous adjustments to problem-solving strategies and helping teachers identify a variety of misconceptions and incorrect manipulations that the students often display in online courses.

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Factors Influencing Teachers' Use of Digital Technology: A Structural Model

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Abstract: Digital technology is widely employed nowadays, and its fast advancement has affected many aspects of daily life and how people live today. However, recent studies have shown that digital technology utilization among teachers, especially in Malaysia, is still not noticeable despite several initiatives being executed. This paper aims to predict the factors influencing Malaysian secondary school teachers' adoption of digital technologies. This will be achieved by identifying correlations between constructs such as personal innovativeness, technology self-efficacy, and digital competence, followed by developing a model using Structural Equation Modelling (SEM). In Pahang, 540 secondary school teachers from 50 public secondary schools in 11 districts participated in a survey. Correlational research has been suggested in order to investigate this issue quantitatively. Participants were requested to fill out a questionnaire of 63 close questions measured using 5 Likert scale points, with answers ranging from Strongly Disagree (1) to Strongly Agree (5). According to the model, personal innovativeness, technological self-efficacy, and digital competence significantly affect digital technology use. The overall structural model with three paths explains 41.9% of the variation in secondary school teachers' use of digital technologies. The paper's conclusion discussed potential explanations for the study's findings and proposed suggestions for further research. These findings highlight the significance of enhancing teachers' personal innovativeness, technology self-efficacy, and digital competence that impact teachers' use of digital technology to meet the requirements of future qualified professions and prepare students for the future digital world.

Keywords: Structural Equation Modelling, Digital technology, personal innovativeness, technology self-efficacy, digital competence

1. Introduction

It is undeniable that digital technology is widely used worldwide, and its rapid development has brought many changes and influenced modern societies. Digital technology has become significant and is part of our lifestyles, work, and society. Redecker (2017) defines *digital technology* as any product or service that can generate, display, share, alter, record, access, convey and obtain information. It comprises computer networks and any online service supported by these, any software, whether networked or installed locally, hardware or device, and digital content. Digital technology is widely employed in education as a mixed medium with a positive effect on academic performance, teaching, and learning in K-12 and postsecondary settings. Digital technology enhances teaching, and, in addition, it also provides teachers with extra resources, better planning, and more tailored teaching methods (Sargent & Casey, 2019; Walan, 2020).

One of digital technology's features is the ability to support learning anytime and anywhere. Murphy et al. (2014) discovered that many students engaged in mobile learning activities while traveling in a vehicle, at work, walking, and in public places. In addition, it stimulates students’ engagement and motivation, and making the class seem more attractive (Omar et al., 2019; Tomczyk, 2020). Digital technology also helps to improve students' focus and perception skills (Loudova & ElHmoudova, 2019). Not only learning with digital tools positively affects student learning outcomes and attitudes (Hillmayr et al., 2020), digital technology has been discovered to affect students' creativity depending on teaching and learning practices as well (Tang et al., 2022). Therefore, it can be concludedthat the use of digital technology in teaching and learning by the teachers can facilitate them in providing an understanding of what the students can learn, although there is a lack of confidence by some teachers in the capability of digital technology to help add value to their teaching and learning.

1.1 Problem Statement

Teachers' lack of access to ICTs or digital technology becomes a major concern in this study. Ebrahimi and Yeo (2018) revealed that ICTs are exclusively used for education by only 57 percent of teachers in Johor, Malaysia. One hundred twenty teachers and 120 pupils from thirty public schools in Johor participated in the study. At the same time, Abdullah et al. (2019) found that the usage of ICT in Malaysia among mathematics teachers remains low in comparison to South Korean teachers. The study was participated in by 71 mathematics teachers from Malaysia and 51 teachers of mathematics from South Korea. These studies reveal that the ICT usage among teachers in Malaysia is still not noticeable, even though several initiatives across Malaysia have been executed. Mynaríková and Novotný (2020) discovered that only 6.5 percent and 0.1 percent of the 1878 secondary school teachers were habitual and frequent ICT users in the Czech Republic. A study of 574 Norwegian and 239 American teachers showed that most had no online teaching experience (Gudmundsdottir & Hathaway, 2020). Therefore, this circumstance compels the researcher to learn more about the aspects that may impact digital technology use among teachers.

1.2 Factors Influencing Teachers' Digital Technology Utilization

According to Agarwal and Prasad (1998), personal innovativeness (PI) is the willingness to accept new technologies and significantly impacts user adoption of new technology. They discovered that people with more excellent PI had a more positive perspective on the technologies they were trying to manipulate. Pinho et al. (2020) explored the factors related to the use of Moodle as a Learning Management System (LMS) and found that PI in information technology positively influences the use of Moodle. Aldahdouh et al. (2020) explore technology use in higher education and the role of the PI in predicting the actual use of social media. Mustafa et al. (2020) discovered that PI significantly impacts the acceptance of virtual reality learning. In this study PI is the extent to which an individual is prepared to adopt digital technology and feels that digital technology will improve his or her teaching effectiveness.

Another factor that can be considered is technology self-efficacy (TSE). TSE refers to a teacher's perceived capacity to integrate digital tools into classroom and to provide meaningful education utilizing relevant digital resources (Holden & Rada, 2011). Thurm and Barzel (2020), who studied the TSE of mathematics teachers, found that teachers with a common belief in technology use in teaching also have a low frequency of technology use. Previous studies showed a positive correlation between TSE and the use of digital technology (Li et al., 2018; Rohatgi et al., 2016). Li et al. (2018) found that TSE was the only significant predictor of teachers' use of technology in general and the use of technology to promote teacher-centered instruction. There is a strong association between teachers' confidence in completing basic digital technology activities and their confidence in utilizing digital technology in online collaboration with students (Hatlevik, 2016). For this study, TSE refers to teachers' belief on their capability to use digital technology.

Digital technology use is often associated with higher digital competence (DC). Krumsvik (2007) defines a teacher's DC as a teacher's capacity to utilise ICT with an excellent understanding of teaching strategy via ICT and to be aware of how this may affect students' learning techniques and educational development. DC in this study refers to teachers' ability to use digital technology confidently, critically, and creatively to convey the content of the lesson to the students. Hatlevik (2016) examines the relationship between teachers' DC and the use of ICT at school. The result showed that teachers' DC could explain variation in teachers' use of ICT. Yazon et al. (2019) examined the relationship between DC and research productivity using digital technology. The study revealed a strong and significant relationship between the two variables. Ghomi and Redecker (2019) and Guillén-Gámez et al. (2020) reported that teachers who use digital tools have higher levels of DC compared to teachers who do not use digital tools. Figure 1 depicts the three hypotheses developed in this study:

H1: Personal innovativeness has a significant effect on the use of digital technology.
H2: Technology self-efficacy has a significant effect on the use of digital technology. H3: Digital competence has a significant effect on the use of digital technology.

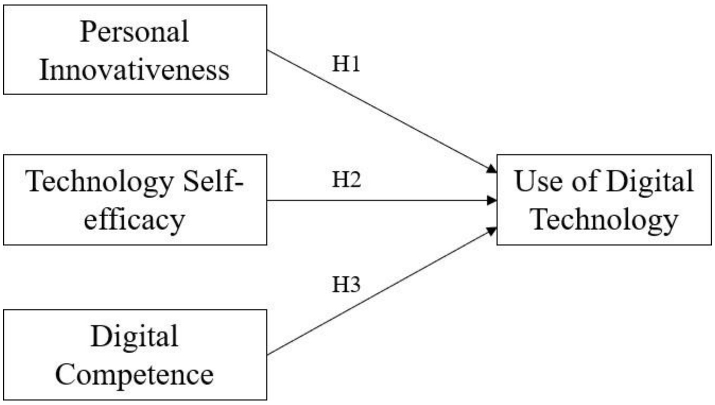

Figure 1. Proposed Model

The literature revealed that Structural Equation Modelling (SEM) attempts had been made in the field of educational technology, specifically for assessing the use of ICT and technology (Hatlevik & Hatlevik, 2018; Gudmundsdottir et al., 2020; Sailer et al., 2021; Jang et al., 2021). The current research aims to investigate the association between PI, TSE, DC, and UDT among secondary school teachers in Pahang, Malaysia.

2. Methods

2.1 Design and Participants

Correlational research was chosen as the research design conducted in this study as it is appropriate to evaluate the relationship between two or more variables in a group. The population in this study consists of public secondary school teachers who teach in day secondary schools in 11 districts in Pahang. In the study context, the teachers involved were those who teach form one to form five students. In total, the study sample comprises 540 teachers. The researchers utilized probability sampling, which includes cluster sampling, stratified sampling, and random sampling, to sample the study. The sampling process began with the number of secondary school teachers in Pahang, then moved on to the number of secondary school teachers by district and school. The school head will appoint a teacher to administer the questionnaire to the respondents, making the selection random as all teachers are eligible to answer the online questionnaire.

2.2 Instrumentation and Validation

The questionnaire was developed and adapted from the previous related studies in English and translated into Malay. The four constructs investigated were PI, TSE, DC, and UDT. The scale for PI was adapted from the Personal Innovativeness in Information Technology (PIIT) scale (Agarwal & Prasad, 1998). The TSE scale was adapted from the Technology Proficiency Self-Assessment Questionnaire for 21st Century Learning (TPSA C-21) by Christensen and Knezek (2016). The DC scale was adapted from the DigCompEdu Framework scale (Ghomi & Redecker, 2019). At the same time, the scale for UDT was adapted from three different study scales done in the past (Hatlevik, 2017; Sadaf et al., 2012; Kamaruddin et al., 2017). The questionnaire was divided into two sections.

Section A was used to collect data on socio-demographic characteristics. Section B consists of four parts relating to the constructs studied. All parts are rated on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Three experts were invited to ensure the instrument's validity based on their experience in educational technology. Corrections were made based on the experts' comments as part of a validation procedure. A pilot study was conducted on 176 teachers from secondary schools in Pahang who would not participate in the actual study. Data collected for the pilot study to assess the instrument's reliability was analyzed using SPSS 26.0. The Cronbach's alpha value varied between 0.810 and 0.962. The internal consistency of the questionnaire is regarded as an acceptable instrument since all values exceed 0.7, according to Hair et al. (2019).

3. Findings and Discussion

3.1 Descriptive Statistics

Table 1 shows that out of 540 respondents in the study, most of them were females (n = 398, 73.7%) and 142 (26.3%) were males. The average age of the respondents in this study was 41 years old. Teachers aged 30 to 39 years old (n = 212, 39.3%) were the majority of the respondents. In terms of race, 94.3 percent (n = 509) were Malay. Most respondents had taught for 16 years or more (n = 261, 48.3%). 284 (52.6%) respondents identified using technology in teaching for less than five years. Only 20.4 percent (n = 110) respondents used technology to teach the class for more than 11 years.

Table 1. *Demographic Information*

Variable	Items	Frequency	Percentage
Gender	Male	142	26.3
	Female	398	73.7
Age (years)	<30	20	3.7
	30 – 39	212	39.3
	40 – 49	190	35.2
	≥50	118	21.8
Race	Malay	509	94.3
	Chinese	17	3.1
	Indian	9	1.7
	Others	5	0.9
Teaching experience (years)	≤5	45	8.3
	6 – 10	72	13.3
	11 – 15	162	30.0
	≥16	261	48.4
Teaching with technology experience (years)	<5	284	52.6
	6 – 10	146	27.0
	≥11	110	20.4

3.2 Construct Reliability and Validity

This study conducted EFA on all sample constructs using IBM-SPSS 26.0. The analysis is suitable to be applied as the survey consists of four constructs with a minimum of 11 variables each. The study collected 176 responses, well suited to the recommended sample size by Tabachnick and Fidell (2019) which is between 100 to 200 respondents. The communalities or correlation r of all items was greater than .30, which indicates a strong association between the variables (Tabachnick and Fidell, 2019)3es. In the end, indicators with missing values are omitted to avoid overestimation (Tabachnick & Fidell, 2019). Items with a factor loading of less than .50 were also deleted, as the standardized loading estimates should be at least .50 or higher (Byrne, 2016; Hair et al., 2019). Three items were omitted from PI, and seven items remained in DC. Meanwhile, TSE has removed nine items, and no items were deleted from UDT. Table 2 shows the factor loading of each item in PI, TSE, DC, and UDT. The Bartletts' Test of Sphericity is significant (p-value 0.05), and the findings showed that the KaiserMeyer-Olkin (KMO) measure of sampling value for PI, TSE, DC, and UDT were 0.937, 0.897, 0.845, and 0.893, respectively, which is outstanding (Awang et al., 2018). As Awang et al. (2018) suggested, Cronbach's Alpha of all constructs has exceeded 0.7. For the Average Variance Extracted (AVE), all the constructs studied achieved more than the suggested value of 0.50, it shows high convergent validity (Hair et al., 2019). Through CFA, four items were deleted, and the remains were as follows: PI (8), TSE (7), DC (6), and UDT (8).

Table 2. *Factor Loadings and Validities for Reliability Test and Convergent Validity*

Construct/Item	Standardized loadings	Cronbach's alpha	Composite reliability	AVE
Personal Innovativeness		.964	.947	.692
PI2	.815			
PI3	.836			
PI4	.868			
PI5	.886			
PI6	.815			
PI8	.850			
PI11	.791			
PI12	.789			
Technology Self-efficacy		.950	.921	.624
TSE4	.796			
TSE5	.746			
TSE6	.805			
TSE7	.831			
TSE9	.845			
TSE14	.722			
TSE16	.778			
Digital Competence		.932	.859	.505
DC11	.689			
DC14	.652			
DC18	.683			
DC20	.747			
DC21	.744			
DC22	.743			
Use of Digital Technology		.938	.936	.645
UDT4	.755			
UDT5	.805			
UDT6	.796			
UDT7	.853			
UDT8	.815			
UDT9	.805			
UDT10	.768			
UDT11	.825			

Table 3 shows the correlation between PI, TSE, DC, and UDT. The AVEs (values in bold) are higher than the squared correlation coefficient (r^2) between each construct. All of the constructs are different; hence the discriminant validity is proven.

Table 3. *Correlation of Constructs*

Construct	PI	TSE	DC	UDT
PI	**.692**			
TSE	.359	**.624**		
DC	.243	.309	**.505**	
UDT	.516	.191	.118	**.645**

3.3 Structural Model

A structural model depicts the relationship between independent and dependent variables (Whittaker & Schumacker, 2022). The findings of the structural model sought to determine if the model was fit and whether the pathways were significant. Additionally, they attempted to calculate the coefficient of determination (R2). Three hypotheses on the structural pathways influencing a secondary school teacher's use of digital technology were tested to determine the relationship between the study's constructs.

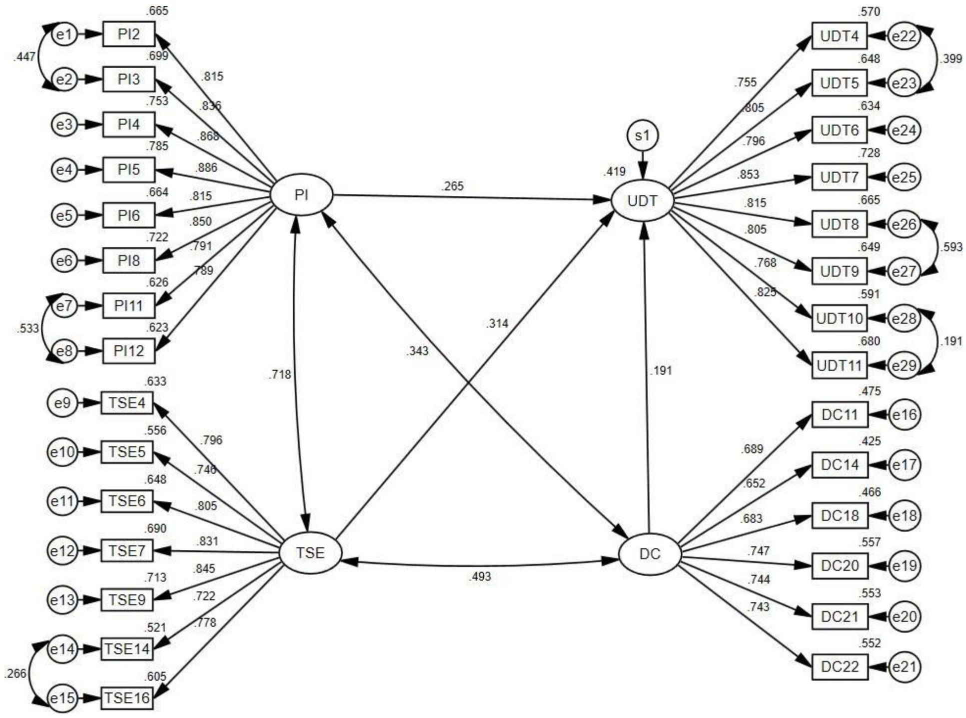

Figure 2. Structural Model

The proposed structural model fit indices in Table 4 showed that the value of x2/df was in recommended range (Bentler, 1990; Meyers et al., 2006). The values of Good of Fit Index (GFI), Adjusted Goodness of Fit (AGFI), Comparative Fit Index (CFI), and Tucker-Lewis Index (TLI) were greater than 0.9, which showed good fit (Bentler and Bonett, 1980; Hair et al., 2019). Lastly, the Root Mean Square of Error Approximation (RMSEA) is also at a reasonable level (Hair et al., 2019; Byrne, 2016). These indexes indicate a good fit for the structural model. Given that the structural model validation results were favorable, there would be no procedure for improving the model (Awang et al., 2018).

Table 4. *Goodness-Of-Fit Indices of Structural Model*

Index	Accepted Value	Model
Absolute Fit		
Chi-Square	p-value > 0.05	0.000
RMSEA	RMSEA <= 0.08	0.040
GFI	GFI > 0.90	0.921
Incremental Fit		
AGFI	GFI > 0.90	0.905
CFI	GFI > 0.90	0.973
TLI	GFI > 0.90	0.970
NFI	GFI > 0.90	0.945
Parsimonious Fit		
Chisq/df	Chisq/df < 5.0	1.878

Table 5 reports the proposed structural model's standardized (β) and unstandardized (b) regression weights. The estimates of the path coefficients confirm the strengths of the links between dependent and independent variables of the study (Hair et al., 2019). The obtained outcome revealed that all three standardized coefficient paths were significant on a critical ratio test at 0.001 level, which needs to be higher than ±1.96 (Byrne, 2016).

Table 5. *Unstandardized and Standardized Regression Weights for The Structural Model*

Path	*b*	S.E	C.R	β	P-Level	Results
PI ❼ UDT	.304	.066	4.579	.265	***	Supported
TSE ❼ UDT	.296	.061	4.858	.314	***	Supported
DC ❼ UDT	.213	.052	4.067	.191	***	Supported

Based on Table 5, the PI ratio and p-value for predicting digital technology use are 4.579 and 0.001, respectively. It shows that PI significantly impacts the degree to which a secondary school teacher utilizes digital technology, so H1 is supported. In addition, the path coefficient is 0.265, indicating a positive relationship. It indicates that teachers who are more open to digital technology and believe it would facilitate their work are more likely to use it. This finding is coherent with many works of literature in existence. This study's results complement the findings of previous researchers who have shown that PI influences teachers' use of ICT (Aldahdouh et al., 2020; Ibieta et al., 2017; Pinho et al., 2020). More than 90 percent of teachers in the study believe that using digital technology helps them perform their tasks more quickly while also improving the quality of their work. Aside from that, teachers believe that digital technology may make their jobs easier. Teachers also acknowledge their intention to extend the use of digital technology in their work in the future. This implies that PI tends to drive teachers to look out for new ideas through various digital technologies in addition to what they have previously provided in the classroom.

Next, the critical ratio and *p*-value of TSE in predicting the use of digital technology are 4.858 and less than 0.001, respectively. To conclude, TSE has an effect on UDT among secondary school teachers. So, H2 is supported. Further, the path coefficient is 0.314, indicating a positive relationship, which means higher levels of TSE are associated with higher levels of UDT. This outcome is similar with several studies that have reached the same conclusion (Lee & Lee, 2014; Rohatgi et al., 2016; Hatlevik, 2016; Li et al., 2018). Teachers generally believe in their capacity to utilize digital technology. Over 60 percent of teachers believe they can use different digital technologies, and emails, search engines, internet platforms, and video conferencing are just a few examples. As a result, as long as teachers believe in their capabilities to utilize digital technology, it is unquestionably a factor influencing their use.

Finally, the critical ratio and *p*-value of DC in predicting UDT are 4.067 and less than 0.001, respectively. The result verified that; DC has a significant effect on UDT. In conclusion, DC predicts UDT among secondary school teachers, so H3 is supported. Further, the path coefficient is 0.191, indicating a positive relationship, which means higher levels of DC are associated with higher levels of UDT. This finding is consistent with the study by other previous studies on teacher's digital competence and technology adoption (Ertmer et al., 2010; Hatlevik, 2016; Sundqvist et al., 2020; Guillén-Gámez et al., 2021). It can be concluded that, as teachers' digital competence increases, their use of digital technology may also increase. This signifies that when teachers get the expected benefits from using digital technology, they will gradually upgrade their digital competence because they believe it is worth using and expect more from it. At the same time, they will begin to practice utilizing digital technology for their jobs or personal lives. These attitudes not only result in an improvement in teachers' digital competence but also in teachers' eagerness to experiment with new technology.

Based on the findings from the inferential analysis, it was found that the proposed model is fit for predicting factors that influence teachers' use of digital technology. Thus, the structural model was calculated using the significance level of R2 measures and path coefficient results. The R2 value of the dependent variable is 0.419 for the use of digital technology. The Coefficient of Determination, or R2 value, is the most frequently applied to assess the structural model. In comparison, the coefficient is observed to measure the predictive accuracy of a model. The coefficient signifies the amount of variance in the latent dependent variable explained by all the independent variables linked to the dependent variable. The value of R2 ranges from 0 to 1. The model explains 41.9 percent of the variation in UDT, with the effects of PI, TSE, and DC being statistically significant. This shows a moderate level of acceptance (Cohen, 2018). For this reason, hypotheses H1, H2, and H3 are supported.The proposed predictive model also indicates that TSE had the most substantial influence on the endogenous variable: the use of digital technology.

4. Conclusion

The results of testing the structural model were consistent with previous studies in the education field. An interesting finding in this research is that, among the predictors of the use of digital technology, the effect of technology self-efficacy is the strongest. The weaker influence of digital competence on the use of digital technology can be interpreted that teachers considering their technology self-efficacy to be more important than digital competence in the use of digital technology. On the other hand, these findings can be justified since the teachers belong to different schools, and differences in how they were instructed, the subject or students that they taught, and how they use the digital technology might have influenced their responses. Significant relationships were verified between personal innovativeness, technology self-efficacy, and digital competence with the use of digital technology. The use of digital technology is a crucial issue to be discussed as teachers nowadays should look into the benefits of digital technologies for their teaching and daily activities.

This study has some implications, both in a theoretical and an applied sense. TSE, PI, and DC are established as the technology adoption factors. In addition, it contributes to the educational technology literature and might serve as a resource for researchers who seek to investigate digital technology use. Aside from that, the study's findings offer helpful information to stakeholders, such as schools, the Ministry of Education, and even third-party training providers, to accommodate better teacher training. It may assist teachers in progressively enhancing their confidence, willingness, and ability to utilize digital technology by planning structured and high-quality digital technology training. Training might involve a revised syllabus to guarantee proper training in increasing teachers' pedagogical use of digital technologies.

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Elementary School Students' Understanding of Nature of Scientific Inquiry: A Preliminary Results and Proposed Practical Framework

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Abstract: With the benefits of the inquiry-based learning environment provides opportunities for students to enquire knowledge in a procedural way by using technology in science classrooms. Similarly, the nature of scientific inquiry (NOSI) is the fundamental understanding of scientific inquiry in which students should know how to do practice to obtain scientific knowledge. The aim of this study was to investigate the understanding about the nature of scientific inquiry in elementary students. A total of 22 participants were involved in this study. A View about Scientific Inquiry for Elementary (VASI-E) questionnaire was administered to capture their understanding of NOSI. Data were analyzed by content analysis and inter-rater reliability techniques. The research results showed that the elementary school students mostly lack of a multiple method aspect regarding understanding about the nature of scientific inquiry. Consequently, a three-layers competency-based inquiry learning activities with supports of digital technology has been proposed as innovative instructional intervention to improve elementary school students' understanding of NOSI, and an illustrative idea is also presented in this paper.
Keywords: Nature of scientific inquiry, inquiry-based learning, technology

1. Introduction

In science education, inquiry is one of the few influential themes that are embedded in school curriculum around the world (Abd-El-Khalick et al., 2004). Scientific inquiry (SI) has been referred to combining knowledge of science topics, creativity, and critical thinking with general science process abilities to investigate nature. (Lederman et al., 2014). Roberts (2008) stated that one of the objectives of science education has been and still is to assist students in forming informed opinions about SI. SI and nature of science (NOS) are often used as synonymous terms. Although SI and NOS are not independent from one another, there is a difference between the two. NOS embodies what makes science different from other disciplines such as history or religion. In addition, NOS refers to the characteristics of scientific knowledge that are necessarily derived from how the knowledge is developed (Lederman, 2006). SI is the process of how scientists do their work and how the resulting scientific knowledge is generated and accepted. This contrast is further supported by the Next Generation Science Standards (NGSS; Achieve, Inc., 2013) which distinguishes between NOS and scientific practices.

From the vision of the National Science Education Standards (National Research Council, 1996), students are required to be able to propose scientific questions and then plan and execute investigations that will provide the data needed to reach conclusions for the stated questions. The Benchmarks for Science Literacy (American Association for the Advancement of Science, 1993) are less motivated in that they do not encourage all students to be able to design and conduct investigations. Furthermore, this situation is found in the Thailand curricula as well. Lederman et al. (2021) conducted baseline research regarding NOSI, the findings illustrate that most of 117 in 12th grade students held naïve or mixed views of six of the eight aspects of NOSI examined in this study. It implied that Thai students failed to express an informed understanding about SI. At the same time, even the research indicated that elementary students can develop an informed understanding of many aspects of inquiry when provided with the appropriate educational circumstances, there is remain significantly less research on the topic of students' understanding of SI than on their performing of inquiry to learn science concepts (Lederman et al., 2013).

Due to the lack of the research which investigates students' understanding about SI, especially in Thailand context. This study focuses on investigating the understanding of NOSI in elementary school students who are beginners of learning science following the basic education core curriculum. Furthermore, the researchers proposed a learning module integrated with digital technologies to enhance their understanding of NOSI. In particular, our research question is what are elementary students' views about scientific inquiry?. In addition, the researchers proposed a practical framework of elementary science learning module for promoting their NOSI with the support of digital learning environments at the end of this paper.

2. Literature Review

2.1 The View About Scientific Inquiry (VASI)

The Views about Scientific Inquiry (VASI) is a questionnaire that has been used to probe not only the student's action while engaged in inquiry activities, but also test the understanding of scientific inquiry (Lederman et al., 2014). The VASI questionnaire was contributed to students in year 7 in a cross-sectional design involving 18 countries as the international collaboration, and a sample size of the study was 2,634 students (Lederman et al., 2019). The findings are intended to investigate assumptions about how the students learn about scientific inquiry in further detail and to provide science teachers and science educators more effective tools for evaluating students' comprehension of key elements of scientific inquiry. The VASI questionnaire is based on the following propositions describing aspects of scientific inquiry about which there is general agreement, and that are both possible and relevant for school children to learn. The researchers recommend the original article by Lederman et al. (2014) for a more description of these eight aspects and their justifications regarding the view about scientific inquiry:

- Aspect 1: Scientific investigations all begin with a question and do not necessarily test a hypothesis.
- Aspect 2: There is no single set or sequence of steps followed in all investigations (i.e., there is no single scientific method).
- Aspect 3: All scientists performing the same procedures may not get the same results.
- Aspect 4: Inquiry procedures can influence results.
- Aspect 5: Research conclusions must be consistent with the data collected.
- Aspect 6: Inquiry procedures are guided by the question asked.
- Aspect 7: Scientific data are not the same as scientific evidence.
- Aspect 8: Explanations are developed from a combination of collected data and what is already known.

Recently, international collaborative research was conducted in 32 countries including Thailand in order to investigate students' views about scientific inquiry in high school level (Lederman et al., 2021). The result illustrated that Thai students held naïve or mixed views of six of the eight aspects of NOSI examined in this study. For the most informed aspect, 47.86% and 41.03% of students exhibited informed views on procedures are guided by the question asked and conclusions consistent with data collected. The most mixed and naïve aspects of NOSI were 67.52% and 69.23% on Procedures influence results and data does not equal evidence, respectively. This implied that it seems Thai students failed to express a qualified view of NOSI.

2.2 Nature of Scientific Inquiry (NOSI) in School Science Education

The fundamental understanding of the nature of scientific inquiry (NOSI) is the comprehension of systematic investigation. In science classroom, Inquiry is typically taught by design the task which allows students conduct investigations or by the emersion of learners in authentic contexts (Sadler, Burgin, McKinney, & Ponjuane, 2010). This is assumed to develop students' knowledge about SI. Theproblematic nature of the assumption can be illuminated by a simple example: students are often asked to control for variables when conducting investigations but may not necessarily have an informed conception of the purpose of doing so, as it relates to the design. Students can participate in inquiry "experiences" but unless instruction explicitly addresses common characteristics of SI, students are more likely to continue to hold naïve conceptions. As Metz (2004) summarizes, "the small research literature examining the epistemic outcomes of inquiry-based classroom instruction indicates that simply engaging students in 'inquiry' is insufficient to bring about these desired changes".

In Thailand context, science teachers are introduced to teaching science under the constructivist view of learning and, accordingly, the main teaching approaches are inquiry-based learning, project-based and problem-based learning. However, researchers have indicated that Thai science teachers place too much emphasis on memorization and assessment driven learning with a focus on fragmented knowledge, rather than scientific inquiry and core concepts (Atagi, 2002; Ketsing & Roadrangka, 2010). There are some difficulties in implementing these teaching approaches. Ketsing and Roadrangka (2010) indicated that the major difficulty is teachers' misconception of inquiry. Science teachers hold a partial understanding of the inquiry concept and do not realize that inquiry is a method for investigating natural phenomena and that scientists use it to gain knowledge based on evidence. Most of the activities that teachers promote rely on a teacher-directed approach. Further, while some teachers are aware of the value and importance of inquiry, in practice, they reject it for a variety of reasons, such as time constraints, the current evaluation policies and values, and cultural and political influences (Faikhamta & Ladachart, 2016).

3. Method

3.1 Participants

The participants in this study consisted of 22 fourth- and fifth-grade elementary school students at a university-based demonstration school located in the northeastern part of Thailand. Their age range is between 10-11 years old. They have experience in learning science following the basic education curriculum in Thailand for four years.

3.2 Instrument

In order to investigate the students' nature of scientific inquiry, the view of scientific inquiry questionnaire (VASI) was employed (Lederman, 2014). The View about Scientific Inquiry for Elementary (VASI-E) questionnaire is a later version of VASI for elementary school science developed by (Lederman et al., in press) was translated from English into Thai by the first author and independently back translated from Thai into English by the second author. This instrument related to the international project which explored the baseline of learner's understanding of nature of scientific inquiry (Lederman, 2021). According to the study, the content validity is confirmed by experts which addressing targeted aspects of SI with 100% agreement. The experts also ensure that all aspect of scientific inquiry is addressed. For construct validity, it can be established if individual evaluators believed to differ in understanding respond differently on a targeted assessment. Sample items of the questionnaire are as follows.

⋆ There was a woman who toured the globe in search of birds. She saw that the beaks of birds came in a wide variety. Some beaks were short and small. Some beaks were long and thin. Some were very big and thick. She also saw that birds consumed a wide variety of foods. She asked, "Is there a connection between the shape and size of birds' beaks and the types of food they ate?" So, then she went out and observed many more birds to try to answer her question. A) Do you think she was working like a scientist? B) Why or why not?

3.3 Students in two groups wanted to know if different crayon colors melted more quickly than others. Group A put 3 different colored crayons under one type of hot light. Group B put red crayons under 3 different types of hot lights. Which group has the better plan? Explain why.Data Collection and Analysis

Each elementary school student was given a VASI-E questionnaire to complete in 60 minutes via the exam online platform. After administering the VASI questionnaire, the results were coded by the primary contact person and science educator colleagues. Each student was given a code of; Informed, Mixed, or Naïve for each aspect of NOSI. In case of elementary school students reply to a response consistent across the complete questionnaire that is completely congruous with the participant response for a given aspect of NOSI they are labeled as 'informed'. If they give a result that is either only partially correct, or if they didn't answer all parts to the question, a score of 'mixed' is given. Lastly, a response that is contradictory to accepted views of an aspect of NOSI and provides no evidence related to accepted views of the specific aspect of NOSI under survey is scored as 'naïve'.

4. Result

4.1 Percentage of Elementary School Students' NOSI

The responses from 22 elementary school student participants obtained by VASI-E questionnaires is concluded in Table 1.

Table 1. *Percentage of elementary school students with naïve, mixed, and informed responses.*

Aspect	Aspects of scientific inquiry	% Naïve	% Mixed	% Informed
1	Begin with a question	9.09	45.45	45.45
2	Multiple methods	22.73	54.55	22.73
5	Conclusions must be consistent with data collected	13.6	31.8	54.5
6	Inquiry procedures are guided by the question asked	13.6	59.1	27.3
8	Explanations are developed from collected data and prior knowledge	13.6	13.6	54.5

All students' responses to the VASI questionnaire were scored by three researchers. This result of elementary school students demonstrated that the highest percentage of informed aspects were *conclusions consistent with data*, *explanation from data and prior knowledge*, *begin with a question*, *inquiry procedures are guided by the question asked* and *multiple methods*, respectively. One possible reason for these informed views is that students obtained opportunities from teachers in this region to develop a conclusion based on the data collected.

4.2 Some General Trends of Elementary School Students' NOSI

Aspects of the elementary school students of understanding about scientific inquiry were ranked from less to more informed in an overview of their characteristics. The top three informed factors in the fourth grade were:

Aspect 5: *Conclusions must be consistent with data collected* (54.5%)
Aspect 8: *Explanations are developed from collected data and prior knowledge* (54.5%) Aspect 1: *Begin with a question* (45.45%)

In contrast, the most naïve views in the fourth-grade sample are found in:
Aspect 2: Multiple method (22.73%)

Aspect 6, that *inquiry procedures are guided by the question asked* exhibited mostly mixed answers with 59.1%.

4.3 Examples of How Students Responded to the VASI-E questionnaire

Here, researchers indicated a few examples of elementary school students in fourth- and fifth-grade students and various aspects of scientific inquiry that responded to the VASI. Researchers follow the order in which the five aspects appear on the VASI-Elementary questionnaire.

4.3.1 Aspect 1, Starts with a Question

The first aspect of the VASI-Elementary questionnaire in questions 4a) and 4b) is about a picture of a different ball. Here is student#1 in fourth grade. She answered in question 4a) about if a friend picked up the ball and bounced it, would they do a science investigation:

"No, because it's a play. He just plays the ball because it's don't have any question before he plays the ball."

And she continues her answer in question 4b, which asks if this particular investigation is an experiment. After that, she answers this question by writing two questions that are shown below:

"1. How high can each of the ball bounce with the same force? 2. Does the weight and size of each ball affect its bounce?"

Moreover, the VASI-Elementary questionnaire in question 1a) related to aspect 1. Here is student#1 in fifth grade.

"Yes, she works as a scientist because she observes birds and she knows the bird how to eat food, each bird has a different mouth."

This was also estimated as an inform answer according to the criteria for the VASI-Elementary scoring. However, it requires more in-depth and demonstrates how research is pragmatic in nature, with research topics frequently changing as new information is discovered.

4.3.2 Aspect 2, Multiple Methods

An example of an informed answer related to aspect 2 was given by student#2 in fifth-grade to questions 1a and 1b on the VASI-Elementary questionnaire, concerning if a scientific investigation always begins with a question about the myth of a single scientific method, approached through an example of observing birds' beaks and eating habits where students are asked if this is a scientific investigation:

1a) "This woman is a scientist because she was observant and tried to find her own answers."

1b) “This woman is not performing a science experiment because she didn't feed each bird, she only surveyed and compared them.”

According to the previous answer stated concerning the use of this crucial idea, the term "experiment" does not appear to have any specific significance to this student other than that it is equivalent to "observing".

4.3.3 Aspect 5 and 8, Conclusions consistent with data and Explanations are developed from data and what is already know

Item two on the VASI-Elementary seeks to create a context to tested aspect 5 and 8. It related to the fossilized bones of dinosaur.

4a)“Scientists know it because there are dinosaur bones and fossil left on it. Moreover, they have surveyed to find more information. However, no scientist has ever seen a real dinosaur. But theyalso knew that dinosaurs existed. Scientists try to compare this bone with another animal, but they cannot find other animals that have the same size as this bone. Therefore, scientists assumed that This bone was a dinosaur bone.”

4b) “Scientists think dinosaur bones are large and many species. Because the bone size is larger than other animals by surveying and comparing the data.”

And an even more answer is given by student#3 in fifth grade:

4a) “scientists know from fossils of dinosaurs that even the dinosaur doesn’t exist anymore, but the bone of the dinosaur existed in some old cave that has a foreign matter or can be a dinosaur painting on it and drawn by people that exist in that era.”

4b) “I think it's because scientists used the bones of large dinosaurs compare with normal animal bones to see similarities. Another reason about the big size of the bones and how many bones were found at the place of the scientists or scientists trying to arrange the bone to turn into a dinosaur figure and observed the sharp teeth. Or maybe taken to examine the gene of the bone to see what it is.”

4.3.4 Aspect 6, Inquiry procedures are guided by the question asked

Item three tested aspect 6 of understanding inquiry by posing a question about which testing group of candles has a better plan from the experiment?. This is an example of an informed response from student 4 fifth grade on elementary school students:

“Group 1 had the best idea of experimenting because group 1 uses the same light source and different crayons, so the experiment makes sense. Using the same light source that makes the experiment fair because we can see which crayon melts first correctly. But group 2 use 3 light sources to experiment will not be fair because if one of the light sources is hotter than the other, that crayon will melt first without knowing which color of crayon melts easiest or hardest.”

These examples demonstrate the quality of answers on item 3 with the most mixed answers responses from elementary school students.

5. Discussion and Conclusion

To summarize these findings in respect to the research topic, the VASI questionnaire revealed that the majority of students in this sample do not have an informed perspective of scientific investigation. This study showed that the highest informed answers of elementary school students is for the aspect of *conclusions consistent with data collected*. Likewise, twelfth-grade students from a public secondary school in Thailand had especially informed understanding about some aspects of NOSI consist of *conclusions consistent with data collected* and *procedures are guided by the question asked*. (Lederman et. al., 2021). In contrast, this study examined the score of nature of scientific inquiry of the elementary school students and found that the highest percentage of Naive views is shown in *multiple method* aspect in both groups, consist of elementary school students (22.73%). The only aspect that has the lowest rate was aspects 2, the multiple methods of elementary school students. These results can be described by the lack of emphasis related to doing inquiry in the classroom. Moreover, this study revealed that the new inquiry learning for elementary school students could not enhance their understanding of the method of inquiry. Obviously, there are other ways that scientists perform investigations such as observing phenomena. Consequently, elementary school students should develop an understanding of the variety of research methodologies in the classroom.

The dimension to consider when evaluating these findings is how scientific inquiry is depicted in the science curriculum in Thailand. Regarding curriculum reform, the ministry of education of Thailand launched a new curriculum, the 2001 Basic Education Curriculum B.E. 2544 (Ministry of Education 2001). Under this curriculum for science education, the Institute for the Promotion of Teaching Science and Technology (IPST) — an agency under the direction of the Ministry of Education–plays a major role in reforming science education and, in 2002, established standards forscience education in Thailand. This curriculum would promote students' learning to acquire scientific knowledge by using essential inquiry skills for investigations, identifying patterns from data, and solving scientific and technological problems. Moreover, the science curriculum requires all Thai science teachers to embed NOS in their science teaching. However, it does not inform science teachers on how to teach NOS. Furthermore, Ketsing and Roadrangka (2010) indicated that the major difficulty is teachers' misconception of inquiry. Science teachers only have a partial understanding of the concept of inquiry and are unaware that it is a strategy for exploring natural occurrences and that scientists utilize it to gain information based on evidence. The following section describes the future work which supports students' understanding of scientific inquiry.

6. Future Work

According to the preliminary results as abovementioned, the researchers plan to design a learning module to foster elementary school students' understanding of NOSI and their learning competencies in science subject matter, and also promote the quality of science education addressing the revised national basic education curriculum. This competency-based science learning module was designed to enhance students' understanding of scientific inquiry by using inquiry-based learning approaches that have the potential for various methods to investigate scientific phenomena. Moreover, the researchers plan to integrate various technologies into the learning activities for emphasize students experience with using digital technologies as the investigation tools in multiple methods of investigation to address the previous result of the study. In addition, numerous researchers have indicated that integrating digital technology into inquiry-based learning activities could engage learners' interaction and also promote their conceptions about science while learning science (Premthaisong & Srisawasdi, 2020; Premthaisong, Pondee & Srisawasdi, 2017; Pondee, Premthaisong & Srisawasdi, 2017; Phouthavong & Srisawasdi, 2016). To foster elementary school students' understanding of NOSI, a series of science learning module named "Water is Life" which includes three layers of competency-based learning activity consisting of (i) NOSI with typical scientific inquiry endeavor related to the Alaskan Grizzly bear and salmon migration, (ii) NOSI with specific context of scientific inquiry processes on how to determine water quality and intervene water cycle for living applications, (iii) NOSI with fake news related the science of water in daily life, respectively.

To provide meaningful and interactive learning experiences to elementary school students and improve their understanding of NOSI, a rich of digital learning environment has been developed to achieve that. In the digital learning environment, students were systematically assigned to interact with several kinds of digital learning materials for the learning of the eight aspects of NOSI through an integration of Moodle learning management system and H5P user-generated content technology. For their interaction, interactive H5P video presentation embedded NOSI components in all eight aspects in the Alaskan Grizzly bear and salmon migration scenario. This video shows natural phenomena and how scientist work to find the answer to why salmon swim upstream and can back to their home. In the video, students will interact with different kinds of interactive elements, and they can also monitor learning progression through the results of video interaction. In the second activity, students collaboratively interact with a digital board game to learn the science concept of water cycle. After, students were assigned to interact with hands-on laboratory stations that encourage students to understand multiple methods of scientific inquiry focusing on water quality concept. For the next activity, students were allowed to encounter fake news related natural water situation to foster their NOSI implementation toward current social life. Table 2 shows the three layers of competency-based learning activity to foster elementary school students' NOSI.

Table 2. *The Three Layers of Competency-based Learning Activity for NOSI Development*

Learning Competencies	Learning strategy	Learning tools	
NOSI with typical scientific inquiry endeavor			
To be able to understand the nature of scientific inquiry	Inquiry-based learning with interactive video	Interactive video	
NOSI with specific context of scientific inquiry processes			
To be able to create a model to explain water cycle phenomena	Inquiry-based with digital board game	Digital board learning Game	
To able to investigate as scientific practice about applying water in daily life	Hands-on inquiry-based practical work	Microcomputer -based learning	
NOSI with fake news			
To be able to use the nature of scientific inquiry to investigate problem	Inquiry-based learning with interactive video	Video interactive & Microcomputer -based learning	

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Trends and Development of Artificial Intelligence in Game-based Learning from 2011 to 2022: A Promising Environment for Learning Digital Citizenship Behaviors in Thailand

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Abstract: This study has reviewed the relevant journal articles about the trends and developments of Artificial Intelligence (AI) in game-based learning in the recent decade (from 2011 to 2022). This study investigated many research issues, such as countries, learning content, learners, and AI algorithms/strategies. Furthermore, this study reveals that AI in game-based learning has been an attractive topic in the development of computers and technology in education, and learning logs have been an essential part of supporting desired learning behaviors. However, only a few studies have conducted AI in game-based learning to promote essential skills in the 21st century. In other words, essential skills have a potential domain with the rapid development of AI. Through the analysis of the trends and developments in the various dimensions of AI in game-based learning, further research directions and challenges in AI-enabled game-based learning regarding promoting desired digital citizenship behaviors, mainly among young Thai students, are discussed in this paper.

Keywords: Quality education, essential skills, lifelong learning, digital literacy, learning behaviors

1. Background and Motivation

With the emergence of new technologies and social media platforms, the increase in internet accessibility has changed the way of humans exchange information and participate in online social activities. The Internet has become an essential part of our everyday life. Especially for the younger generation, those born in the digital age perceive the Internet as a powerful tool for learning and empowerment (Fioravanti et al., 2012; Hong et al., 2003; Valaitis, 2005). Accessing the Internet is becoming an increasingly common substitute for face-to-face interaction, communication, work-from-home, and online-learning activities. The concern for adolescents' well-being and digital safety education, thus, has been raised among scholars (Almourad et al., 2021; Edwards et al., 2018; Richardson et al., 2021; Tapingkae et al., 2020). As citizens of the world, youths of the 21st century are expected to understand their roles as digital citizens, be respectful of others and themselves, and be responsible to the online community. Hence, digital citizenship has been considered one of the necessary competencies by various world-renowned educational and economic policy development organizations (ISTE, 2007; OECD, 2018; UNESCO, 2015). It covers a set of competencies that determines not only human internet behaviors but also a factor determining an individual's learning, indicating how critically and ethically a person processes the information (Hollandsworth et al., 2011).

Various definitions of digital citizenship have been continuously discussed and evolved throughout the past decades. Generally, "digital citizenship" refers to safe and responsible technology usage behaviors. The basic perspective of digital citizenship emphasizes the norms of the individual's behaviors comprised of responsibility, rights, safety, and security in technology use (Ribble et al., 2004). However, as time passed, the concept was extended to the concepts of global citizenship from the perspective of using digital technologies to support social development and humanity (Choi, 2016; Emejulu & McGregor, 2019; Martens & Hobbs, 2015). Additionally, the scope of digital citizenship was mentioned using the term "media or information literacy." Martens & Hobbs (2015) defined media literacy as "a competence and positive engagement with digital technologies regarding creating, working, sharing, socializing, investigating, playing, communicating, and learning. Participating actively and responsibly in the aspects of values, attitudes, skills, and knowledge in online communities at the political, economic, social, cultural, and intercultural levels. Being involved in a double lifelong learning process and continuously defending human dignity."

According to the definitions mentioned earlier, however, the scholars coherently agreed that these two concepts should be harmonized in the field of teaching digital citizenship since literacy, namely a capability to read, write, and communicate to engage as a part of the online community if not all but it stills the fundamental competences and skills leading to a higher level of ethical digital practice (Buchholz et al., 2020; Pangrazio & Sefton-Green, 2021; Saputra & al Siddiq, 2020). Therefore, we review journal articles that lay on digital citizenship and digital literacy in this article. With various teaching and learning strategies during the past decade, technology-enhanced learning or using information communication technology (ICT) has challenged educational reforms in promoting desired digital citizenship behaviors in emerging countries such as Thailand. In the context of Thailand, digital citizenship or digital literacy has been defined as a safe, ethical, lawful, and effective use of ICT. Individuals can appropriately access, evaluate, and create data, information, or content media (Ministry of Digital Economy and Society, 2020). However, the teaching and learning strategies for providing knowledge and proper skills/behaviors to digital citizenships have not been well studied. That is to say, this paper aims to promise an educational position for promoting digital citizenship behaviors in the context of Thailand.

2. Context and Literature

2.1 Definitions and Frameworks of Digital Citizenship/Digital Literacy

Scholars have defined and proposed a framework for digital citizenship in the past decade. According to Ribble (2015), digital citizenship was specifically identified into nine areas of behavior. *Digital access* refers to as full electronic participation in society. *Digital commerce*: electronic buying and selling of goods. *Digital communication*: electronic exchange of information. *Digital literacy:* teaching and learning about technology and its use. *Digital etiquette:* electronic standards of conduct or procedure. *Digital law:* electronic responsibility for actions and deeds. *Digital rights:* those freedoms extended to everyone in a digital world. *Digital safety:* physical and psychological well-being in a digital world. *Digital security or self-protection:* electronic precautions to guarantee safety. The International Society for Technology in Education (ISTE, 2018) mentioned that a good digital citizen should be able to *"advocate equal digital rights and digital access for all, try to understand all points of view, communicate and empathize with other people through digital channels and treat them with empathy, use critical thinking for all online resources and do not share unreliable sources such as fake news or advertisements, use technology to support and develop social goals, give importance to physical, emotional and mental health while using digital tools, use digital tools to collaborate with other people, understand the permanence of the digital world and manages his/her digital identity by taking the necessary measures."*

Additionally, Choi (2016) divided digital citizenship into a multidimensional concept consisting of four dimensions: (1) *digital ethics* defined as responsible, ethical, and safe online behaviors; (2) *media and information literacy* defined as accessibilities, psychological capabilities, and skills to use digital technologies to communicate; (3) *participation/engagement* defines as personally using digital technologies as a tool or platform to participate and engage politically, socio-economically, or culturally online; and (4) *critical resistance* defines as a higher level of online engagement and participation by using digital technologies to achieve social justice and challenge the status quo. Therefore, media and information literacy were considered important resources to fulfill the componentof digital citizenship. On the other hand, Jones and Mitchell (2016) argued that digital citizenship should be differentiated from digital literacy since digital literacy refers to a specific set of computer and internet-based skills. Meanwhile, digital citizenship focuses on practicing respectful behaviors toward others and promoting civic engagement activities online. The Internet can provide important opportunities for youth to exercise positive social skills and engage with their community in ways that may positively impact offline civic engagement.

2.2 AI in Education and Digital Game-based Learning

With the advancement of modern-day digital technologies, Artificial Intelligence (AI), defined as computational machines capable of performing actions that require human intelligence (Chen et al., 2020; Hwang et al., 2020b), has been exponentially recognized as a new possibility to overcome challenges in many different fields (Aguilar et al., 2021; Chintalapati & Pandey, 2022; Enholm et al., 2021; Nguyen et al., 2021). In education, AI paradigms were used for profiling, predicting, assessing, and evaluating students' performances or academic decisions, either working as intelligent tutoring systems or providing support those are adaptive to students' learning needs (Tang et al., 2021). Furthermore, the article also emphasized that the key role of AI in education is to facilitate individual differences and personalized learning. For instance, Hwang et al. (2020a) implemented an adaptive learning system based on an expert system approach to analyze individual learners' affective and cognitive status in a fifth-grade mathematics course. It was reported that the students who learned with the developed approach significantly improved their learning achievements more than those who learned with a cognitive-based adaptive learning system and a conventional learning system, reducing their mathematic anxieties. Moreover, the system also helped students with lower learning performance complete their learning tasks by supplying materials suitable to overcome learning difficulties. Due to this potential, AI-oriented educators can be encouraged to apply AI technologies in enhancing the existing learning approach to fulfill the learning gaps of different learners in the collective environment where individual learning is hard to be precisely personalized.

Regarding the variety of methods for teaching digital citizenship, game-based learning has been recognized as one of the effective approaches to facilitating digital citizenship education (Calvo-Morata et al., 2018, 2020; Chee et al., 2013; De Troyer et al., 2016; Hill, 2015; Tapingkae et al., 2020). It has been mostly recognized as the designed integration of gameplay, subject content, and pedagogy with expected outcomes for learning (Plass et al., 2015). Due to that, game-based learning can highly engage the learners in a safe, joyful, and interactive context-based environment to acquire their knowledge through experience, trial, and challenge with feedback (DeKanter, 2005; Wu et al., 2012). Furthermore, games allow learners to apply their newly founded knowledge in different artificial scenarios to construct meaningful knowledge to overcome contextual challenges (Boyle et al., 2011). Previous research has shown the game's benefit on students' digital citizenship behaviors. For example, Tapingkae et al. (2020) developed a digital game with a formative assessment-based contextual gaming approach which successfully helps secondary students to promote respectful and tolerant online behaviors and civic engagement, as well as motivation to learn and learning perceptions. However, the challenge of designing a successful game for learning depends on the balance between the flow of content, enjoyment, and learning strategies that is adequate to provide the learning benefits and suitable for the individual differences of the learners. Therefore, the technology-enhanced element in the game should be adaptive to personalize the learning experience to match individual learners' needs (Ravyse et al., 2017).

To cope with the above concerns in the design and development of game-based learning, the argumentation of AI applications or AI techniques to enrich adaptivity in game-based learning has been brought to scholars' attention. The game design components supported learning cover AI-based functionalities, such as personalization, game difficulty balancing, assessment, player analytics, competence modeling, social gamification, language technologies, and affective computing (Westera et al., 2020).

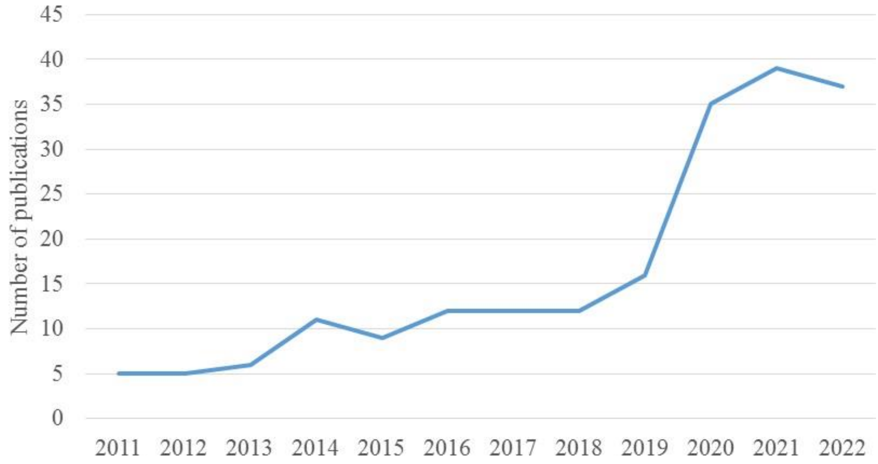

Figure 1. The number of Scopus Indexed Journals' publications on Artificial Intelligence in game- based learning from 2011 to 2022 (August).

Inspired by a growing number of articles related to artificial intelligence in game-based learning, as shown in Figure 1, a systematic review of literature must be conducted to indicate the trends and challenges in development, implementation, gaps, and contribution to future research. However, the recent review on artificial intelligence in games mainly focused on the AI methods in game development (Fan et al., 2020; Zhai et al., 2021) or other fields of the content subjects such as public health (Rafiq et al., 2021). Therefore, it is challenging to focus on using AI in game-based learning that would be promising to teach digital citizenship behaviors.

3. Methods

3.1 Data Collection and Processing

The systematic literature reviewed the research studies conducted from 2011 to 2021 based on the review process of the previous research (Hwang & Tsai, 2011; Xie et al., 2019). The SCOPUS database was selected as the data source due to its high journal quality standard that is reliable and accepted among scholars. The search was conducted by combining two sets of words addressing artificial intelligence in game-based learning, yielding the search query ("artificial intelligence" or "AI" AND "game-based learning" or "game"). To observe the trend and developments of the concerning topic, the publication period was set as a decade between 2011 and 2022. The publication type was set as "article" in the categories of "social science," only written in English. The search results showed 199 articles in total. In order to make sure the articles were relevant to artificial intelligence in game-based learning in education perspectives and excluded commercial perspectives, they were carefully read and selected with the inclusion criteria. Each article must be relevant to proposing AI methods/techniques/strategies to support gaming functions/interfaces and implementing concrete gaming activities. That is to say, 118 irrelevant articles were excluded from the list, and the remaining 22 articles formed the final dataset for analysis.

3.2 Coding Scheme

The four main categories of coding schemes are used to investigate and analyze the trends and developments of artificial intelligence in game-based learning.

(1) Codes for authors: The basic information of articles is queried to understand which countries have more frequently contributed research and published articles about artificial intelligence in game-based learning.

(2) Codes for learners: The codes aim to categorize the participants according to their education levels, including elementary school students, primary school students, secondary school students, higher education students, and other and non-specified.

(3) Codes for the learning content: The codes include various disciplines, such as science/engineering/computer science, natural science, social science or social studies, skills, literacy, and other and non-specified.

(4) Codes for the AI methods/mechanism/strategies: As Hwang and Tu (2021) suggested, the codes for AI methods/mechanism/strategies are user-oriented and relevant to support gaming functions/interfaces and implement concrete gaming activities. For example, *evolutionary algorithms* (i.e., genetic algorithm, ant colony, tabu search), *fuzzy set theory*, *deep learning/neural networks* (i.e., voice-to-text translation), *case-based reasoning* (i.e., making decisions based on similar case studies from experts in the field), *data mining/personal recommendation* (i.e., classification, grouping, association rules), *traditional machine learning approach* (i.e., creating decision tree based on case studies from experts in the field to lead or support classification or decision making), *statistical learning* (i.e., linear regression, polynomial regression for prediction or reasoning), *natural language processing* (i.e., chatbots with freestyle conversational user interface), and *knowledge elicitation methods via interviewing domain experts* (i.e., repertory grid, EMCUD for developing expert interviewing domain experts systems).

4. Research Results

4.1 Countries

The countries of the authors who contributed to the published articles on artificial intelligence in game-based learning were counted in this study. From the results, it can be found that many researchers from different countries worldwide attempt to apply artificial intelligence in game-based learning. Figure 2 shows the distribution of the countries. It was found that the top five countries are the United States (5), the United Kingdom (4), Taiwan (3), Netherlands (2), Portugal (2), and Sweden (2).

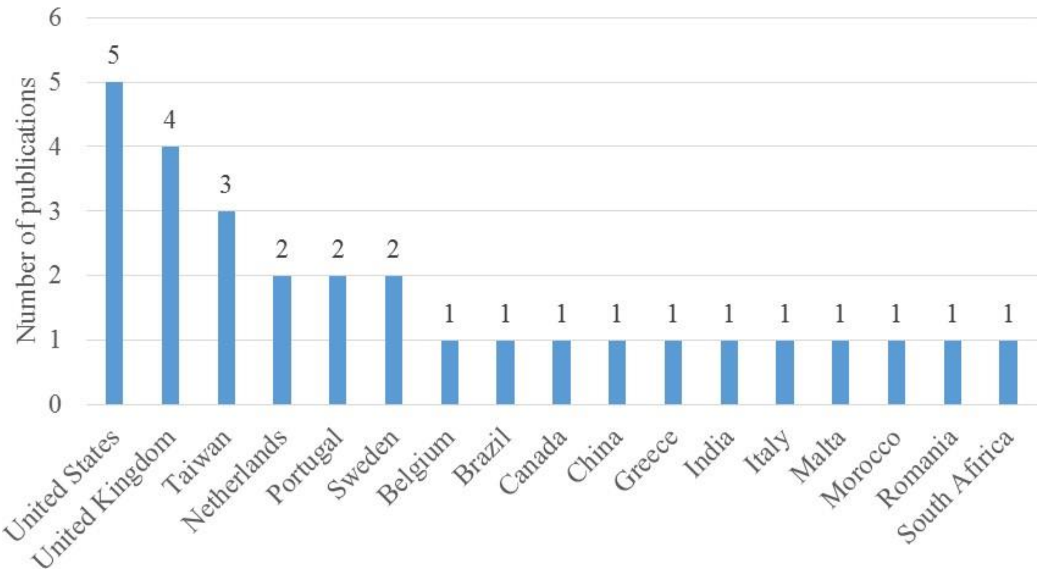

Figure 2. The distribution of countries contributed to artificial intelligence in game-based learning during 2011-2022 (August).

4.2 Learners

As shown in Figure 3, about 27% (6 out of 22) of the research studies relevant to artificial intelligence in game-based learning often selected primary school students as the participants. Higher education students are the second group of learners chosen as the participants in the research studies. Meanwhile, it was found that the frequency of elementary and secondary school students recruited as participants in the research studies is less than the above two groups of learners. It is worth pointing out that increasing the number of research studies relevant to artificial intelligence in game-based learning is challenging. It could be another perspective for a more understanding of how artificial intelligence in game-based learning could help elementary and secondary school students' learning.

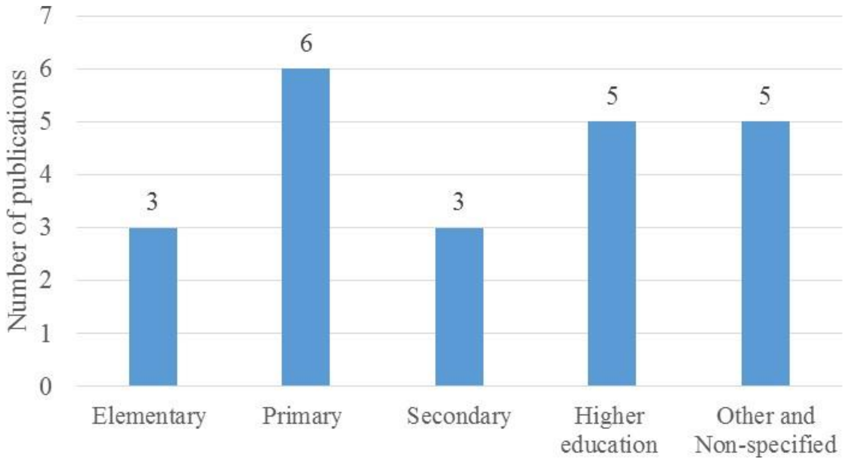

Figure 3. The distribution of learners contributed to artificial intelligence in game-based learning during 2011-2022 (August).

4.3 Leaning Contents

As shown in Figure 4, the most popular learning content is science/math/engineering/computer science, accounting for 32% of total research studies, similar to Xie et al.'s (2019) study on technology-enhanced adaptive/personalized learning. Another category of learning content, "other and non-specified," involved 8 studies unrelated to a specific subject. It involves students' perceptions and feelings of AI applications in the games and investigation of efficient AI techniques. However, in game-based learning studies, science/math/engineering/computer science and skills were frequently chosen as the learning content in artificial intelligence. It was found that other categories, such as social science/social studies and literacy, were seldom selected in the artificial intelligence in game-based learning studies. Future study is worth showing the potential of using artificial intelligence in game-based learning to promote learners' performance in social science/social study courses and literacy as essential skills in the 21st century.

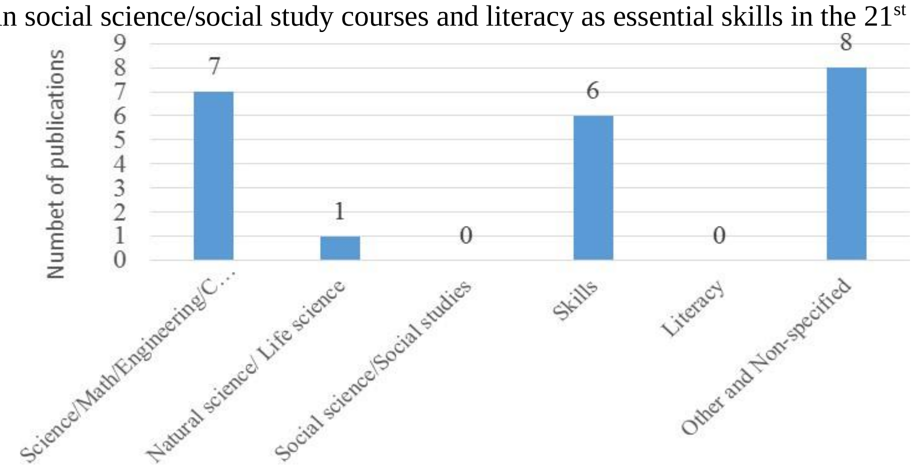

Figure 4. The distribution of learning contents contributed to artificial intelligence in game-based learning during 2011-2022 (August).

4.4 AI methods/mechanisms/strategies

Figure 5 illustrates the distribution of methods/mechanisms/strategies contributed to artificial intelligence in game-based learning. As revealed in Figure 5, the most AI methods/mechanisms/strategies employed to develop game-based learning are deep learning/neural networks, accounting for 36% of total research studies. The second methods/mechanisms/strategies of AI is data mining/personalized recommendation with a frequency of 31%. That is to say, most researchers often apply existing applications in the App Store or Google Play to teach learning content for learners. Some researchers prefer to take students' characteristics/ emotions/ behaviors to adapt gaming activities for individuals. The least frequent AI methods/mechanisms/strategies were genetic algorithms and the traditional machine learning approach as the decision-tree technique. These results might be conveyed that the traditional machine learning approach as the decision-tree technique can stimulate or situate gaming activities in which learning content.

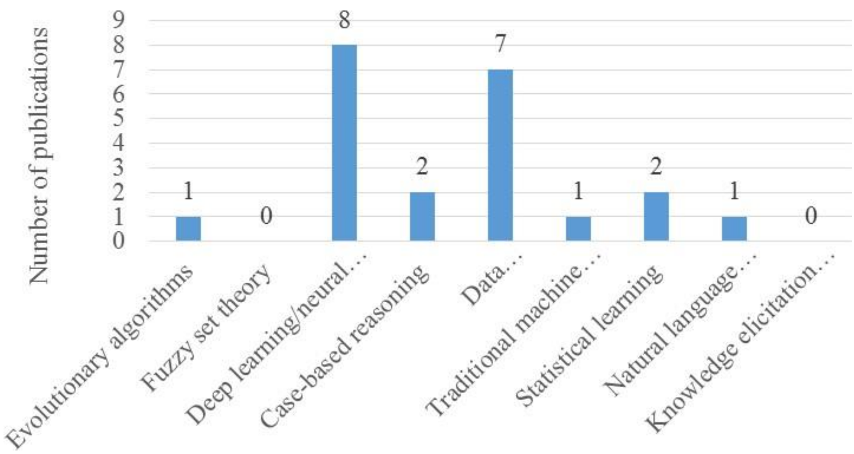

Figure 5. The distribution of methods/mechanisms/strategies contributed to artificial intelligence in game-based learning during 2011-2022 (August).

5. A Promising AI in Game-based Learning for Digital Citizenship Behaviors in the Thailand Context

This paper shows the results of a meta-review about artificial intelligence in game-based learning studies published in academic journals from 2011 to 2022 (August). It was found that the number of research studies in this area greatly increased over the years in many countries. It implies that educators or researchers worldwide are increasingly interested in developing game-based learning using AI methods/mechanisms/strategies or AI applications. In the meantime, Thailand was not found in this investigation, showing the opportunity and challenge for improving Thai students' learning performance using artificial intelligence in game-based learning. In addition, from the frequency of publications, it was found that learning content related to social science/social studies "literacy" was seldom conducted for artificial intelligence in game-based learning. Therefore, it is worth investigating the effectiveness of artificial intelligence in game-based learning on learners' performance in these subjects, especially in essential literacy related to "digital citizenship/digital literacy" in the 21st century. On the other hand, it can be found that several AI methods/mechanisms/strategies, such as fuzzy theory, knowledge elicitation methods via interviewing domain experts, genetic algorithms, and traditional machine learning approach as the decision-tree technique, were rarely adopted in game-based learning. Therefore, it is worth investigating the potential and possibility of applying or integrating them into game-based learning. In particular, the traditional machine learning approach as the decision-tree technique could benefit the learners in deciding their possible behaviors' consequences.

From the above concerns, promising learning environment for AI in game-based learning to promote desired behaviors of digital Thai citizenship in the future study are listed as follows:

(1) In Thailand, the office of the national digital economy and society commission, the

Ministry of Digital Economy and Society of Thailand, has established a digital literacy handbook for Thai citizens (Ministry of Digital Economy and Society, 2020). That is to say, digital citizenship/digital literacy has been defined as a set of competencies associated with the responsible use of ICT. Its framework consisted of *(a) access* includes definition, search/find, access, and retrieve of the information; *evaluation* includes understanding, assessment, evaluation, and organization of the information; *(b) creation* includes creation, communication, participation, and monitoring of the information; and *(c) use of tools and technology* refers to the competencies to execute various equipment, process, techniques, or innovations for accessing, evaluating and creating data, information, or content media appropriately. This establishment aims to enhance the citizens' knowledge, understanding, awareness, and skills on the creative use of digital technology as a tool for sustainable human development. Topics include: *digital rights* covers learning the rights and responsibilities as a digital citizen, *digital access* relates to learning the foundation of data, information, internet system, and how to use digital tools to acquire information efficiently, *digital communication* refers to learning the principles of online communication and privacy, *digital safety* is learning to protect oneself and avoid the risks from digital threats, *media and information literacy* according learning to critically analyze, interpret, differentiate, and evaluate the value of the information and its sources, *digital etiquette* involves learning the ethics and manners in using online technology and social platforms empathetically, *digital health* concerns with learning the physical and psychological impacts of the Internet and digital technology on individual's well-being, *digital commerce* associate with learning the essential elements of online marketing and making safe transactions, and *digital law* refers to learning the rules related to intellectual copyrights and digital economy in order to identify crime and penalty or the actions. The primary and secondary school Thai students have been taught and practiced to access learning management systems or online learning platforms, to use social media for group discussions or as digital tools, and use email for submitting the assignment or receiving relevant learning material.

That is to say, Thailand's basic education core curriculum mentioned by the Office of the Basic Education Commission of Thailand aims to promote good behaviors and daily life habits when the students participate with Internet access, social media platforms, and digital tools. As suggested by the Common Sense Media curriculum (2016) and Tapingkae et al. (2020), the research-based curriculum relevant to digital citizenship or digital literacy would prepare students to behave safely in cyberbullying, digital drama, digital relationships, digital relationships, and online communication. Therefore, the potential topics for conducting the digital citizenship behaviors or digital literacies for Thai youth students are following:

- Cyberbullying or be upstanding: the students should be able to reflect on what it means to be brave enough to stand up and help others both online and offline, understand the feelings of cyberbullying people (Cyberbullying) or intimidation by using digital technology, and find solutions to help cyber-bullying people;
- Safe online talk: it involves descriptions of the positive aspects of texting and chatting online, identification of inappropriate and risky friendships or making friends, flirting, and conversation situations, and understanding of the rules for safe online messaging and a sense of power to deal with awkward situations when communicating online;
- Reality of digital drama: it refers to reflecting feelings about stories that happen in the digital world, comparing the messages that convey the stories that happened in the digital world and the real lives of teenagers, thinking critically about Gender stereotypes and general conclusions;
- Cyberbullying (crossing the line and making correct decisions): includes analyzing online bullying behavior that leads to crossing the line, learning about the bullying behaviors in the online world (e.g., flaming, deceiving, and harassment), and applying the perspective of people who have been bullied in the online world as a solution when faced with cyberbullying incidents.

(2) Applying the traditional machine learning approach as the decision-tree technique to create a storyline to trigger the students' good decisions.

(3) Applying instructional design as context-based learning to design gaming activities to situate the students' behavior aforementioned-item (1) digital citizenship behaviors or digital literacies.

(4) Analyzing learners' behaviors and interactive patterns in gaming activities with the decision-tree technique to understand changing and adapting undesired behaviors to desired behaviors.

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Blended Learning Practices among Chinese Secondary School Teachers: The Untold Stories

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Abstract: The development of intelligent campus construction for primary and secondary schools in Guangdong Province, China has enabled Chinese educators to realize that promoting the transition from primary and secondary school teaching to blended learning (BL) would become the primary goal of future basic education development. However, Chinese educational research scholars have rarely studied the application of BL theory in secondary schools. The implementation of BL in secondary schools continues to face multiple challenges. This study explores the BL model successfully implemented by teachers in the context of secondary schools in Guangdong Province. A total of 13 teachers participated in the interviews, and results are analyzed using thematic analysis techniques. Data analysis results show that teachers acknowledge the positive impact of BL on students, but they lack the motivation to actively implement this method. The negative experience includes eight categories: teaching resources, teacher–student interaction, student self-control, student academic performance, network environment, learning platform, observing students, and workload. Findings will propose new research thinking to propel the implementation of BL in secondary schools.

Keywords: Blended learning, secondary school, teacher perception

1. Introduction

With the continuous emergence of emerging technologies, educational researchers and practitioners are aware that new changes in learners and the media environment make the old educational system unable to meet the needs of the new generation of learners. Blended learning (BL) is a method formed after people's profound reflection on face-to-face teaching in traditional classrooms and distance online learning. Huang et al. (2022) believed that the education management department could promote the deep integration of information and communication technology (ICT) and education by promoting the development of hybrid education. In BL, teachers can actively adapt to new technologies, such as artificial intelligence, in teaching. Primary and secondary schools expect to change the existing teaching model through BL and solve the problem of students' personalized learning being limited (Cheng & Wu, 2020). However, minimal research has been conducted on application effects in primary and secondary education and understanding of curriculum design-related theories remains relatively weak (Fu et al., 2021). Although the effective implementation of BL brings new learning experience opportunities and good learning outcomes for students, it will also present additional challenges for secondary school teachers. Undeniably, teachers play a vital role in the educational reform process driven by new technologies. However, conducting research on BL implementation and assessment rarely begins with teachers' perceptions (Mozelius, 2017). The current study aimed to investigate the experiences of secondary school teachers in Guangdong Province in effectively implementing BL. The findings revealed the relevant factors that promote teachers' acceptance of BL based on their perceptions. Therefore, the research question of this study is as follows: How could the BL model be implemented effectively in secondary school courses?

2. Methodology

2.1 Participant

This study invited secondary school teachers who had implemented BL. Those who participated in the interviews have previously joined the Information Technology Upgrade Project 2.0 (ITUP 2.0) and had over three years of work experience in implementing BL. These teachers can provide relevant in-depth, extensive information on effectively implementing BL. The researcher conducted the study through semi-structured interviews. Eventually, 13 secondary school teachers were willing to share their experiences and expressed interest in participating in this study.

Table 1 shows the demographics of the teachers interviewed. The participants' work experience was between 3 and 15 years. Six participants' schools were in the modern city, while those of the other seven were in towns or remote areas.

Table 1. *Participant Demographic*s

Groups	Subgroups	Percent
Gender	Male Female Total	15.38 84.62 100.00
Title	Junior title Middle title Total	46.15 53.85 100.00
Type of school	Public Private Total	53.85 46.15 100.00
Experience as a teacher	3–5 years 6–10 years 11–15 years Over 15 years Total	53.85 15.38 23.07 7.70 100.00
School area	City Rural /Town Total	53.85 46.15 100.00

2.2 Data collection

The researcher considered the actual situation of the respondents with the help of online platforms (e.g., Zoom, Tencent Meeting) and email to achieve data collection. The semi-structured interview outline consists of 5 descriptive and 12 open-ended questions. Interview questions were validated by three experts in BL and qualitative research and modified according to their guidance. The researchers transcribed the raw data from the interviews and subjected them to further analysis.

2.3 Data analysis

The data analysis used in this study was thematic analysis, which follows the six-stage guideline proposed by Braun and Clarke (2006). The researchers also used the qualitative data analysis software ATLAS.ti 22 for classification and relationship representation. To ensure the reliability of the coding process, the researcher sent the interview data back to the interviewed teachers for confirmation and invited peer experts to check the data coding.

3. Results and Discussion

3.1 Advantages of BL implementation

The teachers who participated in the interviews agreed with the advantages of BL from various aspects. However, their recognition of the benefits of BL is not based on their own professional satisfaction or willingness but on the degree to which students benefit from the BL process. This view is shown in the following seven aspects:

(1) Students' learning breaks time and space constraints, and the classroom is no longer bound by geographical location (Participants C01, C02, R01, R05, and R07).

(2) In BL, students learn more "autonomously," and "personalized learning" is easy to achieve (Participants C02, C04, R01, R02, and R05).

(3) Problems students encounter in learning can be solved promptly (Participants C06, R03, and R04). In the classroom, teachers can use tablets to "see students' feedback on problems intuitively" (Participant C06). In homework after class, teachers can track problems encountered by students promptly.

For example, Participant R03 explains this aspect by stating:

"[...], I can use the platform to complete the correction of students' homework and use the platform to track the problems encountered by students." Participant R04 also agreed with this aspect:

"I can find out the problems of the students in time. I can make good use of the teaching platform to monitor the progress of each student's course. I can get timely feedback on the problems encountered by students through online exercises."

(4) Teachers can give individualized instruction to students (Participants C04 and R02).

(5) Multi-faceted learning resources can meet the needs of students (Participants C06 and R06). Participant C06 indicated that in BL, "The resources for pre-class preview and after-class review are much richer than before, [...]." "These rich teaching resources expand student's knowledge" (Participant R06).

(6) Students are markedly interested in learning (Participants C03, C05, C06, R03, R04, and R06). For example, Participant C06 described as follows:

"[...] Not only that, the student's interest in learning is significantly higher. When asking questions in class, because students have tablets in their hands, the feedback on the questions is more intuitive."

However, Participant R03 went a step further and believed that owing to students' strong interest in learning, he did not need to design or think of specific ways to motivate students. The reason is that students are already extremely "active" in blended learning.

(7) The learning platform can give students rewards, which relatively improves students' interest in learning.

For example, Participant C04 described the experience of using the blended learning platform:

"The UMU platform has a reward mechanism. When completing tasks, they will get a certificate, which can motivate students to complete tasks quickly. Teachers can also pay attention to each student's learning situation in the background monitor." Participant

C04 has a similar expression:

"[...] Our students have always been very motivated in the blended learning process as they can get rewards with points upon completion, which can exchange for gifts at different levels."

The study results showed that the interviewed teachers did not state that an advantage of BL is improving students' academic performance. They focused on students' positive impact on the learning process compared with traditional teaching models. First, the blended learning model enables students to become considerably flexible and autonomous in their learning styles, supporting the views of Birbal et al. (2018) and Jonker et al. (2018). Second, the BL model promotes teacher–student interaction. The teacher–student interaction emphasized by the interviewed teachers is that they can actively respond to students' questions and give personalized guidance. Many scholars have agreed on this advantage of the BL model (Mena, 2019; Dakhi et al., 2020; Lozano-Lozano et al., 2020). However, Dakhi et al. (2020) emphasized that the improvement of teacher–student interaction is to compensate for the embarrassment of students when they talk or ask questions in class and is markedly conducive to emotional communication between teachers and students. Other scholars have focused on discussionand collaboration in student learning activities. Teacher–student interaction in the BL model increases students' participation in the learning process (Mena, 2019; Lozano-Lozano et al., 2020). Third, students showed significantly high interest in learning during the BL process. Students' interests positively impact learning and academic performance (Osman & Hamzah, 2020; Wu et al., 2019). From the statements of teachers who participated in the interviews, the researchers believe that a relationship exists between the learning platform and students' learning interests. The learning platform can promote students' participation in the classroom, and the reward function within the platform can stimulate students' interest in learning.

Although only a few teachers interviewed raised the topic of the advantages of BL from the teacher's perspective. Participant R06 proposed that one of the advantages of BL is to enhance the ability of teachers to apply information technology. In addition, BL improves teaching efficiency (Participant C03, C04, R03, and R07).

3.2 Negative experience with BL implementation

The analysis of the interview records shows eight negative experience themes among the interviewed teachers. Table 2 shows the distribution of negative experience themes of the interviewed teachers.

Table 2 *The Distribution of Negative Experience Themes*

Themes	Percent
[insufficient] Teaching resources	61.53
[difficult] Teacher–student interaction	38.46
[weak] Students self-control	76.92
[dissatisfied] Student academic performance	30.77
[poor] Network environment	38.46
[not perfect] Online platforms	53.85
[difficult] Observing students	23.08
[heavy] Workload	46.15

Through in-depth analysis of the meanings and causes of themes projected in the interview records, the researchers established the relationship between the negative experience themes, as shown in Figure 1. Thereafter, the researchers will analyze the relationship among these themes.

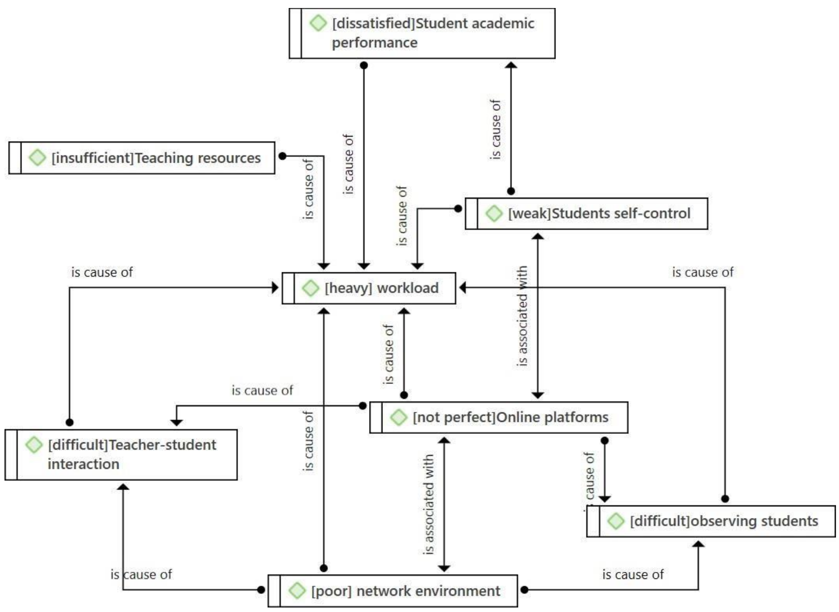

Figure 1 Relationship among negative experience themes

(1) [weak] Students' self-control. The interviewed teachers believe that BL has high requirements for students' self-control. First, the open network environment (Participant C01 and C03) and novel features in the learning platform (Participant C04) distract students. Therefore, an interrelated relationship exists among "[weak] Students self-control," "[not perfect] Online platforms," and "[poor] network environment." Second, Participant C01 believed the following ideas:

"Students [...] cannot complete online learning entirely independently." Similarly,

Participant R02 stated as follows:

"Students with poor self-control are more likely to be seduced by other resources on the Internet, resulting in low learning efficiency and poor learning effect."

Therefore, "[weak] Student self-control" leads to "[dissatisfied] Student academic performance" results that cannot meet teachers' expectations for students.

Lastly, owing to "[weak] Students self-control," "Additional time for teachers to tutor after class increases the workload" (Participants R01 and R03). Note that "[weak] Student self-control" also causes teachers to "[heavy] workload" is one of the reasons.

(2) "[insufficient] Teaching resources" give teachers a negative experience. The reason is that the resources provided by "online platforms" cannot meet the needs of teachers. Therefore, teachers devote a long time searching and preparing teaching resources, resulting in a "[heavy] workload." For example, Participant R02 said "the time cost of needing suitable teaching resources is high in the massive teaching resources."

Participant C02 also stated the negative experience of teaching resources:

"Mainly refers to the teacher did not prepare class resources before class. There is also the content of the online part, and we must enter and debug the equipment in advance. The teaching resources on the platform also need to be repeatedly confirmed."

Therefore, the researchers express the causal relationship among "[insufficient] Teaching resources," "[heavy] workload," and "[not perfect] online platforms."

(3) "[not perfect] Online platforms" are the essential hardware support for realizing the BL model. Therefore, online learning platform and network are inseparable, and the relationship presented between them is also interconnected. "[not perfect] Online platforms" and "[poor] network environment" affect teachers' observation of students' learning behavior (Participant C02, R01, and R02") and also affect the interaction between teachers and students (Participant C02, C03, C05, and R01).

From the intensity of the theme, the researcher found that students' ability is among the important reasons for the negative experience of teachers. This conclusion is consistent with previous research results (Chen & Cao, 2020; Liu & Wang, 2021). Many scholars have acknowledged that implementing a BL model will increase the workload of teachers (Brown, 2016; An et al., 2021). The analysis of the relationship among the negative experience themes can help the interviewed teachers find the workload and underlying reason for the increase.

3.3 Teaching resource support status

Differences are also observed in the support status of teaching resources in different regions. Developed cities, such as Shenzhen and Guangzhou, can meet the needs of teachers in terms of teaching platforms and teaching resource support. Teachers are minimally satisfied with the teaching platform in ordinary cities and remote areas. Owing to the differences in the teaching materials used in various regions, the effect of applying the teaching resource platform provided by the government is also affected (Participants R02 and R03). Lacking appropriate teaching resources led teachers to call for schools to build their teaching resource plate (Participants R05 and R06).

4. Conclusion

The result of teachers' perceptions of the effective implementation of BL models in secondary schools can be concluded in two categories: teachers' perceptions of the advantages of BL and negative experiences. Teachers' recognition of the advantages of BL is not based on their professional satisfaction or willingness but on the extent of benefit of students in the BL process. That is, teachers lack intrinsic motivation to implement BL. Seven types of negative experiences affect teachers' implementation of BL. Students' self-control, online platforms, teaching resources, and workload arethe factors with high impact strength. In summary, ITUP 2.0 has realized the transformation of secondary school teachers adapting to the application of new technology in teaching. Teachers can actively and effectively implement BL in the current environment. However, given that challenges continue for secondary school teachers in BL practice, some contents close to the actual operation should be added in future trainings. Moreover, project lecturers can consider combining excellent learning platforms and digital resource application cases for promotion. While improving teachers' information technology competencies, sharing of practical BL experiences should be ensured. In the future, we will further expand the sample from teachers' perspective to investigate the optimization mechanism to promote BL development in secondary schools.

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The Use of Constructivism Flipped Classroom to Promote Analytical Thinking in the Technology Course

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Abstract: The flipped classroom has recently been a popular learning approach., In the Thai context, it was found that most of the flipped classroom use was to passively assign students to study content outside of school hours, preventing students from developing advanced thinking skills. Therefore, this research aims to use constructivism to design a flipped classroom and examine the students' analytical thinking results to compare the analytical thinking of the learners in the experimental and control groups by performing a quasi-equivalent control group (design). The participants were divided into a control group receiving (learning in a traditional flipped classroom, and an) experiment group participating in the constructivism flipped classroom. Both groups were 11th grade students. The research found that the experimental group had higher analytical thinking scores than the control group.

Keywords: Constructivism learning environment, flipped classroom, Analytical thinking

1. Introduction

The modern world is known as the era of information due to the rapid contact of news stories, with technological advancements causing economic change. In the 21 century, education management today has adopted innovation and educational technology to increase learning options. To develop learners in the age of globalization to have knowledge and ability to analyze. Synthesize information and news A teaching methodology that emphasizes interpersonal differences. The teaching process changes the role of teachers from being givers. The broadcaster becomes an educational designer to develop different people. The learning trajectory began to enter the era of using "intensive technology" to learn things (Kanjug, 2013). Teachers need to be ready to provide instruction to the changes in time for the advancement of technology today regarding learning patterns or processes.

The advancement of technology affects the student's learning abilities. However, classroom management still encounters many difficulties, such as the organization of teaching activities focusing on the teacher center and teaching styles such as chalk and talk. Those concerns are about how teachers teach the students by ignorance of students' learning preferences. It might affect learners lacking in understanding or unable to create their own body of knowledge. Currently, teaching and learning focus on the learner as a center (Child Center), focusing more on the learners and encouraging all learners to develop according to their potential and interests. It would be more considering the fundamental differences of learners. That is to say, the learners will discover and solve problems by themselves and have more freedom to study. They are able to build a body of knowledge by learning from various situations, both inside and outside the classroom. Teachers, therefore, have to change their roles as facilitators for the learners (Kanjug, 2013).

Additionally, the problem of computational science courses was found to be a new course in basic compulsory subjects from the revision version of the Basic Education Core Curriculum of Thailand. Regarding the curriculum, teachers still need more information about teaching techniques and innovations to support their teaching. In addition, a few subjects were complex for learners to learn. It is necessary to study according to the specified process and reduce learners boredom, increasing their learning interests with analytical thinking rather than memorization. Otherwise, the learners would misunderstand the learning content and might bring knowledge to solve further other problems.

Regarding the concerns above, instructors need to reshape how they manage their learning classroom corresponding to their learners by, enabling them to learn independently based on technological materials with a suitable learning environment. Teachers can choose a learning management method appropriate for the context of the school and the learner. Therefore, flipped classroom learning is a teaching process that transfers from direct instruction or passive learning to active learning—such as an interactive learning environment that face-to-face learning in class and online self-learning. Teachers would be intellectually guided to enable students to apply their maneuvers and creativity in the subjects.

The inverted teaching and learning management model is different from the traditional teaching and learning model. Flipped classroom teaching and learning will focus more on enabling learners to create knowledge on their own based on skills. Knowledge, ability, and intelligence, according to the rate of learning ability of each person (self-paced learning), are gained from experience provided by teachers through various types of information technology and communication. It is also a characteristic independent of learning from sources outside the classroom regarding ideas and practices (Kanjug, 2013).

On the other hand, analytical thinking is divided into five steps: 1) Matching, 2) Classification, 3) Linking, 4) Conclusion, and 5) Application, which requires reasoning skills. Deep and diverse thinking is thought through and rational considerations by identifying similarities or differences, enabling one to rank, categorize, or categorize knowledge of things, and identifying reasons for data errors. That is, the students would be able to interpret or impart basic criteria of knowledge, specify, be specific, or draw a reasonable conclusion. until it can become new knowledge (Marzano, 2001).

Therefore, this study recognizes the importance of developing the flipped classroom learning environment to promote analytical thinking in the technology course (Computational Science) for secondary school students and aims to solve learning management problems as mentioned above. It is based on the design and development of the conceptual framework, where learners can learn technology and contribute to the linkage of new knowledge.

2. Literature Review

2.1 Constructivism Learning Environment Management System

The theory of constructivist learning is vital to understanding how students learn. The idea that students actively construct knowledge is central to constructivism. Students add (or build) their new experiences on top of their current foundation of understanding. Woolfolk (1993) stated that "learning is active mental work, not passive reception of teaching." The fundamental principle is that knowledge is constructed, learning is a social activity, learning is an active process, learning is contextual, people learn to learn, learning exists in mind, knowledge is personal, and motivation is key to learning. A learning environment focuses on solving problems and developing a student's conceptual framework (Jonassen, 1999). The learning process is generated from relation or previous understanding, in which the learners attempt to gather the experiences or situations to form the intellectual model. Therefore, there are important principles in applying the concept of constructivism theory used to design technology and organize learning environments. A constructivism-based learning system is an online management system developed based on elements of constructivist theory (Kanjug et al., 2018).

2.2 Flipped Classroom Learning Environment

The concept is turning the classroom lecture into classroom activities. The lecture should be done outside the classroom or through video and online media. By doing this, students will have more chances to participate and interact with their teachers and friends (Bergmann & Sams, 2012). Teaching science has changed from teaching. Direct instruction or passive learning becomes more active through an interactive learning environment that connects face-to-face learning and online self-study. The teacher will be an intellectual guide. To enable students can apply concepts and creativity in various subjects.

The effective flipped classroom learning management model is based on learning management through constructivist theory (Constructivism), which focuses on learners building knowledge through experience and action through thought processes by linking previous experiences and real contexts to create new knowledge. The learning environment is meaningful for students regarding meaningmaking by stimulating problem situations (problem-based learning). It allows students to analyze problems and make alternatives. With a wide range of possibilities, decide on a context-appropriate approach to creating work in that learners must discover new knowledge by seeking answers from learning sources, collaborating to learn and solve problems, and exchanging ideas and cognitive processes. The teachers were coaches or guides who advised and encouraged learners to think to create knowledge independently. Reverse learning is another learning environment that integrates teaching and technology, as illustrated in the Learning Environment Framework for Inverted Classrooms (Kanjug, 2013).

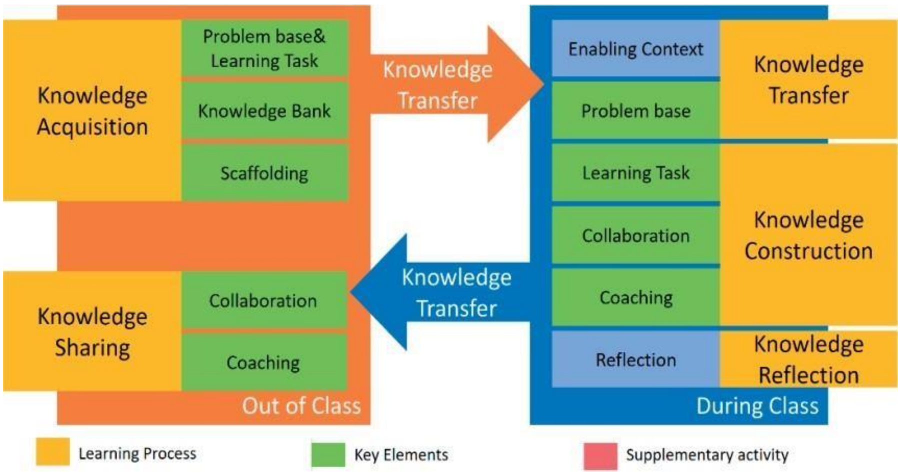


Figure 1. Demonstrate a conceptual framework for organizing the learning environment for the flipped classroom (Kanjug, 2013).

As shown in Fig 1, this learning management conceptual framework focuses on enabling learners to create experiences outside the classroom to gain basic knowledge or understanding of the content. Before expanding knowledge of concepts and depth through classroom activities, the students would go back to review the reflection about what they have learned after completing the course. Through this self-study outside the classroom, the learners will focus on developing the ability to transfer knowledge and experiences through self-learning outside the classroom and hands-on classroom activities (Kanjug, 2013).

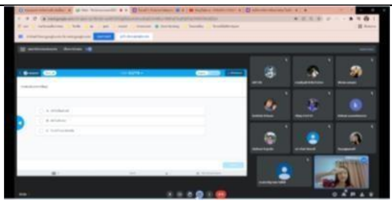
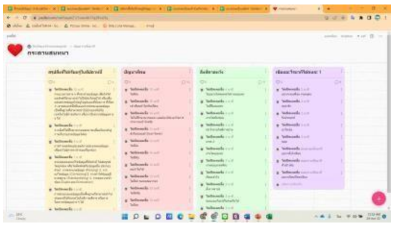
2.3 Analytical thinking

Analytical thinking is a rational expansion of thought. It applies the analytical process and the information's specifics based on knowledge. The original understanding accumulates in short-term memory in a small intelligence structure and independently generates new information. The students would be able to summarize the necessary specifics, characteristics, and unnecessary information (Marzano, 2001).

3. Methodology

3.1 The design Flipped classroom

Table 1: *An example of the learning process in Flipped English reading comprehension Learning classroom adapted from Kanjug et al., 2016.*

Components	Description of the learning process	Example of learning activity
Learning material: SOCIAL Classnet		
Out of Class (Pre-Class) Knowledge Acquisition (1) Problem base & Learning Task (2) Knowledge Bank (3) Scaffolding	The teacher explained how to use online learning. In SOCIAL Classnet format Based on the Constructivism Learning Environment Management System	
Learning material: Teaching reading comprehension as an Acti ve Learning		
In class Knowledge Transfer - Problem base Knowledge Construction - Learning Task - Collaboration - Coaching Knowledge Reflection - Reflection	- The teacher created the online quiz. In order to achieve the learning process in the classroom in the order of steps. - Students collaborated to learn and exchange ideas with members of the group. At the same time, the teacher will be a coach to provide guidance.	 
Out of Class (Post-Class) Knowledge sharing - Coaching - Collaboration	- Teachers are supportive, support and advise students. - Teacher and students share their knowledge, opinions, and questions about problems that arise while carrying out classroom activities through social media such as Facebook, SOCIAL Classnet, etc.	 

3.2 Experimental Research

This study aimed to examine the validity of flipped classroom learning materials to promote critical thinking in technology courses (Computational science). It consists of checking internal correctness and external validity check. The study in this phase consisted of two groups of students performing a quasi-equivalent control group design to examine analytical thinking and achievement. Moreover, they investigated the satisfaction of the learning environment. Experts validated the learning environment.

3.2.1 Participant

The two groups are in this study as follows:

- The experimental group: 23 students received the proposed learning environment.
- The Control group: 22 students receive the traditional learning environment.

Experts are the following:

- Expert in computational science and teaching
- Expert in Design and Educational Technology

3.2.2 Research Instrument

- A flipped classroom learning environment quality assessment form aims to measure analytical thinking in technology courses (Computational science) for experts.
- Technology Achievement Measurement Form (computational science)
- Analytical Thinking Ability Test
- Student satisfaction assessment form with a flipped classroom learning environment to promote analytical thinking in technology courses (computational science)

3.2.3 Data Collection and Analysis

1) Test before studying with an analytical thinking test and an achievement measure Technology (Computational Science)
2) Students in the experimental group study in the flipped classroom learning environment. The students in the control group studied in the usual way.
3) Students in the experimental and control groups test after studying with an analytical thinking test. and achievement model Technology (computational science) subjects and students in the experimental group took the satisfaction assessment after learning in the learning environment flipped classroom.

4. Results and Discussions

Regarding the student's analytical thinking, the researcher had to do the test after studying with a form to measure the analytical ability of the learners. It is a four-choice multiple-choice test created by the researcher by measuring the analytical thinking in 5 areas; there are 10 items, divided into 2 items each, with a total score of 25. The results are shown in Table 2.

Table 2. Students' analytical thinking results

Sample Groups	N	$\bar{x}$	S.D.	τ	Sig. (1-tailed)
Experimental group	23	21.85	2.40	9.048	.981*
Control group	22	14.20	3.21		

*.05

In scores of analytical thinking, the experimental group had a mean score after learning activities of 21.85, and the control group had a mean score after school of 14.20. When comparing the scores of the two groups, it was found that the mean scores for analytical thinking were a significant difference at the .05 level. These results reflect that the students have gained more analytical thinking from classroom activities, reinforcing their thinking process to solve problems.

According to the theory of constructivism, learners acquire knowledge by experiencing and developing their wisdom by themselves (Glasersfeld, 1991). Constructivism theory emphasizes developing internal knowledge related to previous experiences (Kanjug, 2004). Learners should gather their perceptions together with understanding to create their cognitive structure (Chaicharoen, 2011).

The concept is turning the classroom lecture into classroom activities. The lecture should be done outside the classroom or through video and online media. By doing this, students will have more chances to participate and interact with their teachers and friends (Bergmann & Sams, 2012). Teaching has changed from direct instruction or passive learning to active learning in an interactive learning environment that connects face-to-face learning and online self-study. The teacher will be an intellectual guide. To enable students can apply concepts and creativity in various subjects (Kanjug, 2013), it allows students to view the content of the course lectures from media used outside the classroom. In the classroom, it is practiced to do homework problems. It is the concept of a Traditional Flipped Classroom (Patamathammakul, 2012). This study introduces a good combination of constructivist theory and flipped classroom model. Active learning by using new technologies or multimedia helps learners to access the world of knowledge easily, enhance their experience and finally acquire their intelligence.

In summary, this study designed and developed the flipped classroom learning environment to promote analytical thinking in secondary school students' technology course (Computational Science). This development could be beneficial for improving learners' ability to identify problems, analyze and create methods for solving problems by themselves, facilitate self-learning, and gain self-experiences.

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Design of Collaborative Ubiquitous Learning in Promoting Digital Education: Integrating History, Science, Technology in Reflection Class

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Abstract: This paper attempted to present the Design of Collaborative Ubiquitous learning approach in promoting Digital Education in the integrated study called "Reflection Class". The concept of this integrated History, Science, and Technology content used in this study was called "Story-based learning". Besides, the learning activities were designed to support learner's collaborative ubiquitous learning. This process required learner's effort to work in group through the virtual online platform in order to inquire the Concept, Collaboration, and Content from class within 1 month. The learners received and responded to this CULD approach the high level of learning achievement in the context of 3C; Concept, Collaboration, and Content. Furthermore, the finding of this study could bring more digital education approach supporting the variety of learning approach during Covid-19 outbreak and Life-long learning.

Keywords: Collaborative Ubiquitous learning, digital Education, story-based learning, Reflection

1. Introduction

Nowadays, the concept of Collaborative Ubiquitous Learning in the field of Education can be expressed to a particular vantage point and with certain positions. Specifically, it tries to examine two different lenses of perspectives: the social studies in learning, and another one is, the digital science and technology. Story-based Learning has been an approach in the recent years, because of its impacts on learning experiences and outcomes (McQuiggan et al., 2008). This concept, obviously, is narrative-centered learning in which combines historical contexts and pedagogical strategies. According to McQuiggan et al, their research makes it clear that Contextualizing learning within storytelling significantly affects students' learning outcomes by plots and settings. Not only the ability to understand any lessons, but also claimed to reflect the natural way people understand and remember stories, data, and information, revealing in a close correspondence with the familiar experiences of daily life (Graesser et al., n.d.).

Science and Technology was an essential part of students' learning in the 21st century (Raja & Nagasubramani, 2018). In this path-breaking critique of the relationship between Social Studies, Science and Technology, Crowe (2004) argues that Science and Technology had been gradually recognized in the field of Education together with Social Studies (Alicia R. Crowe, 2014). To make this point clearly, there are some discussions about its positive effects in the field of Social Studies (Kafadar & Kafadar, 2020). According to Kafadar 's result, he mentioned that the majority of students stated Science and Technology helps them to improve their communication to interacting easier with teachers and colleagues in class. Another tremendously outstanding effect of its advantage relation between Science & Technology and

Social Studies is to extend student' s motivation and eagerness to learn this course by encouraging them with the use of computing and digital devices to enhance their self-efficacy and self-worth.

There are many different explanations of this approach, such as "Web-based training, Online learning, Network learning, Distance learning (Cross & Dublin, n.d.). Lin defined the digital learning as delivery with digital forms of media through the Internet (Lin et al., 2017). In this present, it rapidly develops as the virtual learning. In particularly after the epidemic of Covid-19, virtual learning replaced the traditional learning wholly. Schack examined the advantage of online learning; Increased inclusivity, Improved accessibility, Community, and relationship building, and Greater flexibility and comfort (Schack Noesgaard & Ørngreen, n.d.). In addition, the software supporting Virtual learning approach rapidly grow. For instance, Zoom, Microsoft Teams, Padlet, Mentimeter, Canva, etc. Which allow learner to collaborate and work in group conveniently.

According to the phenomena of Integrated digital learning under the concept of Story-based learning, therefore the collaborative ubiquitous learning is adopted as an efficient learning promoting the Digital education in Reflection class, the integrated learning's activity supported Teamwork, and Ubiquitous learning called CULD. The concept of CULD encouraged learners to learn and work collaboratively through the Virtual platform. Moreover, these developed activities promoted Historical, Scientific, Technological knowledge content, and context.

2. Related Study

2.1 Collaborative Ubiquitous learning and Integrated Studies

Collaborative Learning (CL) is one of the most ubiquitous educational concepts in the twentieth century, thanks to its shifting from individual learning to group work (Laal & Laal, 2012; Leonard & Leonard, 2001). In this sense, meaning is an educational approach in which is relevant to groups of student's activity so as to solve an issue, complete a task, and generate some ideas or tangible basis products in the class (Macgregor, 1990). There can be no doubt that Collaborative Learning will involve students directly, especially CL activities that allow students to talk, work, and join closely together in small group.

It is possible that the effect of the complex and advanced technology is the differentiate of education. This does not only allow students and teachers to access a number of resources available online (Zhang et al., 2005), but it also makes a huge impact on the learning and interaction of educational approaches (Raja & Nagasubramani, 2018). According to Mottus et al, their definition of Ubiquitous Learning (U-learning) is the learning supported by mobile, computers, or wireless networks to provide students with content and interaction anytime or anywhere (Mottus et al., 2018). However, its significant features was a rise in the numbers of the omnipresent learnings both in virtual and electronic resources that assist students deal with the real world (Peng et al., 2008).

There are some particularly large advantages of Collaborative Ubiquitous Learning. For example, it facilitates access to students by the number of information and data online using mobile devices (Debora Barbosa, 2016). Moreover, Guozhen Zhang and Qun Jin, had also revealed that this technique led to the increase of the availability of mutual and friendly help in the learning process (Zhang et al., 2005). Although Collaborative Ubiquitous Learning had many benefits to students in recent years, we cannot deny that this approach has some disadvantages, such as scalability concerns (Debora Barbosa, 2016).

Due to its advantages mentioned above, we are not surprised that the increasing trend of Collaborative Ubiquitous Learning has been widespread in recent years. This sign revealed some data that many educational institutions implied this technique in their classes. However, In Thai context, according to Panjaburee and Srisawasdi, they indicated that the studies about Collaborative Ubiquitous Learning have been frequent in the last-two decades at all levels (Panjaburee & Srisawasdi, 2018).

2.2 Digital Education

Digital education or E-learning is always considered as the innovative use of digital tools and technologies during teaching and learning called Technology Enhanced Learning (TEL)(Camilleri & Camilleri, n.d.).In addition, Digital learning involves the communication technologies to support the learner interaction with digital materials in order to help learners reach specific learning outcomes (Mayende et al., 2017).
Nevertheless, according to the digital learning's definition, they recognized as an overview of various learning pedagogy that replaced traditional method by combining technology as follow: Blend learning, Online learning, Differentiated learning, etc.

After the epidemic of Covid-19, teaching and learning pedagogy continuously develop. Digital learning replaced traditional learning inevitably. In addition to various learning approach mentioned, Virtual World greatly assimilate throughout many platform (Baker, n.d.). There are emerging online learning platform supported the Virtual learning such as, Zoom, Microsoft Team, Miro, etc. in ordered to learn in fully-virtual world. Takacs & Pogatsnik opined that this great increasing online learning platform change education perspective wholly (Takacs & Pogatsnik, 2021). In the other hand, there are some effects of digital learning, in particular learners. Phalitnonkiat founded that digital learning has a positive impact on student learning motivation. In the context of communication skill, and digital learning effected negatively to student's communication's performance (Phalitnonkiat et al., 2020).

The concept of Digital education have continuously developed. In particular after the epidemic of Covid-19, there are many learning platforms supporting the integrated studies. For instance, Project-based learning, STEM, etc. According to Sumarmi, designed the Project-based learning through digital platform (Sumarmi et al., 2021). Similar to Chang, studied the STEM student's performance between Vietnam and Taiwan in order to design the curriculum for STEM (Chang et al., n.d.). Nevertheless, there are many online learning platforms popularized to work collaboratively, such as, Padlet, Miro, Mentimeter, Google slide, Jamboard, Canvas, etc. Saudra opined that these platform support in the context of Group communication. In the other hand, Linda opined that the learning platform strengthen the student concept knowledge (Linda et al., 2021).

3. Description of Collaborative Ubiquitous learning in Promoting Digital Education

3.1 Background and Overall Structure

Reflection class were designed to reflect the student's learning performance in Grades 10^{th}-12^{th}. Each semester was set for which students were required to study predetermined period. Based on the concept of story-based learning as follow. In each semester content and skills that students would learn were be consorted with the historical timeline in order to integrate knowledge content in many disciplines such as Mathematics, Physics, Chemistry, Biology, Engineering, and History, etc. Student's learning was divided into 4 modules. Each module, students would summarized in Reflection activity. Instructor designed the learning activity using the expected learning outcome, Key concept, and the context that learners could gain in 1 month. Every Reflection class were designed into Group Work that learners could collaboratively work.

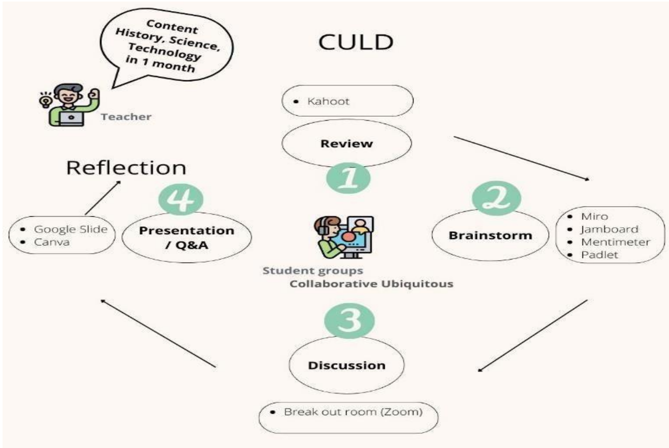

Figure 1. The Overall Structure of collaborative ubiquitous learning in promoting digital education (CULD).

According to Collaborative Ubiquitous learning process in Reflection class, Digital education were used as the channel and platform in this class. Owing to learning collaboratively through the virtual platform, Digital education is an essential tool supporting Ubiquitous learning integrating knowledge's content from student, and credible online database through online learning platform. For instance, Zoom, Kahoot, Miro, Jamboard, Mentimeter and Canva, etc.

3.2 Design of Learning Process

According to the overall structure of CULD, the learning activity are designed by taking Learning Outcome, Key Concept, and Context as main criteria to design learning process in each month within 2 hours.

Table 1. *Learning Process in Reflection class*

Time (Minutes)	Activity	Particular	Digital Platforms
10-15	Introduction /Review/Check in	An Introduction was encouraged learner's attendance with some online clips on YouTube. Review section, Mentimeter was utilized to recheck what lessons they had recently learnt in last 1 month by sending some texts or messages.	YouTube, Kahoot, Miro, Padlet, Mentimeter
60	Main activities (Give assignment)	In the Main Activity, purpose to check students' comprehension, teachers' s role gave some questions related to the topic in each class. Due to the number of students in the class, instructor divided them into a Breakout room approximately 6-7 people for students and 1 teacher in each group in order to allow them to ask, answer, and participate effectively. Some example questions in the class For 12th Grade, the 1st Module, the question is how technology affected the development of scientific knowledge in late 20th Century - Physis, Chemistry, Biology, and Engineering (select one subject on above), and the last asked what its effect on humans was. Skill acquired are Collaboration, Teamwork.	Miro, Canva, Google Slide

20	Group Presentation	Skills acquired are Collaborative Skill and Presentation.	Miro,Canva, Google Slide
10	Q&A, Discussion	Presentation and Q&A section between teachers and students.	

4. Research Design

4.1 Participant

There were 120 Grade 10-12th students who participated in this research study. All student joined the Reflection Class as the supplementary course to integrating every subject in each month within 2 hours for active learning through the virtual learning platform.

4.2 Procedure

The procedure of CULD in Reflection class comprised of four learning process which are presented in Figure 2-3.

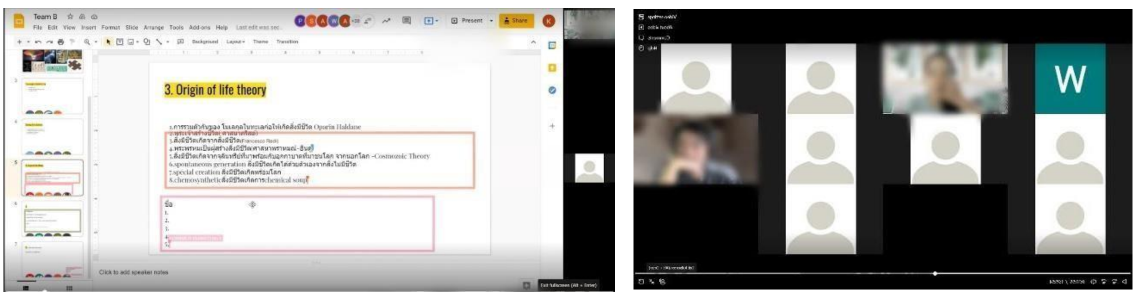

Figure 2. Main Activity, learners developed CULD during brainstorm and discussion in Breakout Room.

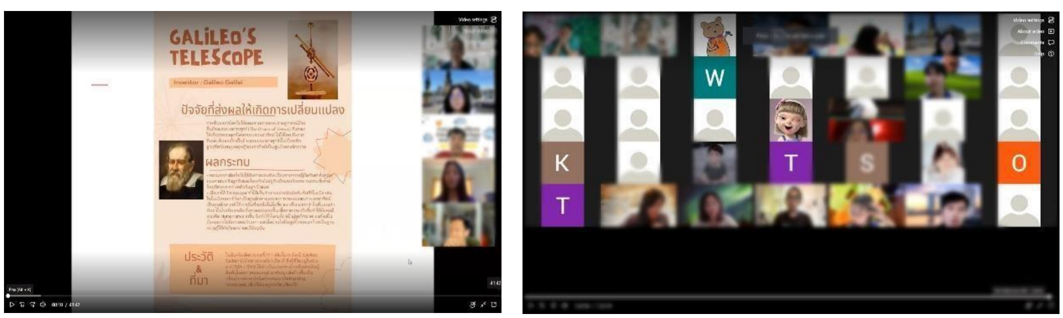

Figure 3. Group Presentation and Q&A and discussion / Teacher and students summarizes the lesson.

4.3 Data analysis

Story-based learning skill performance was conducted from 120 students who attended reflection class. Questionnaires were designed into 6 items that include the concept, collaboration, and content variables. All quantitative data were analyzed using mean and standard deviation while qualitative data were analyzed using percentage evaluation and present in pine chart using excel. For example, of question, Is Reflection help nurthering student's ability to connect knowledge's content? Is Reflection help student's comprehend the key concept of knowledge's content?

5. Result

5.1 Learning Achievement

Table 2. *Self-evaluation about the advantages of reflection activity; 3C* (*Concept, Collaboration, Content*)

Items	Mean±SD
1. Concept; The students thought the reflection activity was "very important" which help students' understanding the concept of all content that they learn each month.	3.74±0.77
2. Collaboration Skill: The students thought the reflection activity was "very important" which help nurturing the students' ability to connect their knowledge of different subjects.	3.91±0.88
3. Content; The students thought they have gained knowledge, ideas or experiences from the reflection activity.	3.78±0.83

Based on the Self-evaluation about the advantages of reflection activity, it founded that most learners have a good attitude toward CULD activity at high level in various context as shown in Table 4 (M = 3.91, SD = 0.88 in Collaboration skill) because most of learning activities developed and increase the collaborative performance integrating Historical context with Science and Technology's content. However, in others context also still performed at level (M = 3.78, SD = 0.83 in Knowledge Content and M = 3.74, SD = 0.77 in Concept).

6. Conclusion

In this context, there can be no doubt that the Reflection Activity Class puts in a relatively advantageous position students who were in need of work together as a group. One of the consequences was an increase in the number of students' capabilities acquiring both in an academic and in experiential soft skills. As a result of such a learning atmosphere. Firstly, in this Reflection Activity Class provided students with unlimited questioning to some situations, events, and issues by the utilization of a number of disciples and fields to enquire. Next, due to its importance of learning in the 21st century, the intention of applying technology in this activity also allowed them to generate and create boundless conversation with colleges, teachers, and others both in class and after that. Finally, the Reflection Activity Class with using the online technology can be defined in the new ways following Cope and Kalantzis (2007) concept as "to blur temporal boundaries of education". Its meaning is learning, and education can happen anywhere, anytime, and anybody.

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Impact of Prolonged COVID-19 Pandemic on the Social Networking Sites Usage and Psychological Distress among University Students

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Abstract: The primary aim of this study is to determine the purpose of social networking sites (SNS) usage and the severity of psychological distress among university students after experiencing a prolonged coronavirus disease 2019 (COVID-19) pandemic. A total of 112 university students completed the questionnaire adapted from the Social Networking Usage Questionnaire (SNUQ) and the Depression, Anxiety and Stress Scale – 21 items (DASS-21). Descriptive results showed that the university students use SNS actively for entertainment purposes, followed by academic, social, and information purposes. The students also suffered from immense psychological distress, with anxiety being the highest, followed by depression and stress. The results indicated the potential of integrating SNS in instruction and urgency in resolving the critical psychological distress issue among university students.

Keywords: social networking sites; SNS; psychological distress; university students; COVID19

1. Introduction

It has been over two years since the Malaysian government declared the first movement control order (MCO) due to the coronavirus disease 2019 (COVID-19) pandemic. Since then, university students' teaching and learning experience has been disrupted as all tertiary institutions were mandated to close, and instruction was forced to be carried out via online platforms like social networking sites (SNS). The Malaysian Communications and Multimedia Commission (MCMC) (2020) has found that internet usage among university students increased significantly from 2018 to 2020, and they use the internet mainly for social, information, and entertainment purposes. This could mean that the SNS usage among the students increased too.

During the same period, studies have found that that university students are experiencing severe psychological distress such as depression, anxiety, and stress that is mainly due to the fear of contracting COVID-19, the challenges in remote learning and financial stress (Sandhya, 2021; Sundarasen *et al.*, 2020). According to Malaysian National News Agency (2022), Malaysia's border has reopened starting 1 April 2022. As the standard operating procedures become less stringent, there is a need to find out the current situation regarding the extent of SNS usage and the severity of psychological distress among university students. This is so that the educational stakeholders like policymakers, educators, and students can have clarity on suitable next steps in terms of the SNS usage and emotional distress among the tertiary students can be taken effectively.

2. Related studies

Psychological distress has become a worldwide phenomenon; over 300 million people suffer from depression globally, and nearly 800, 000 people take their own life each year; it was the second leading cause of death among people aged between 15 to 29 in 2019 (WHO, 2021). Malaysia is facing a similar issue too. Three of every ten Malaysians aged 16 and above suffer from mental distress, and it was predicted that this trend will continue to surge (Institute for Public Health, 2015; Institute for Public Health, 2019). This pertinent problem of emotional distress was further aggravated with COVID-19. Sundarasen *et al.* (2020) did a study with 983 university students in Malaysia. They concluded that one-third of the students underwent mild to extreme psychological distress. A survey by Sandhya (2021) found that 85% of 520 respondents with mostly university students, experienced depression, anxiety, and stress. Given the trend of heightened psychological distress among university students, it is crucial to determine their mental state in the current situation of the pandemic, as emotional wellbeing is the foundation of students' success in learning.

Since the emergence of SNS, the SNS technologies and users have grown drastically (Erfani *et al.*, 2021), even more so during the global crisis of COVID-19, as physical events were prohibited. Al-Dwaikat *et al.* (2020) conducted a study with 456 university students in Jordan and found that the students used SNS primarily for entertainment purposes. A survey done in Malaysia mentioned that socialization, searching for information, and entertainment were the more prominent purposes of internet usage (MCMC, 2020). Although it was shown that internet usage has increased, there lies an uncertainty on the purpose behind using SNS among university students in Malaysia.

3. Objectives of the study

The primary objective of this study is to determine the purpose of SNS usage and the severity of psychological distress among university students during the prolonged COVID-19 pandemic. The purpose of SNS usage measured in this study comprises social, academic, information, and entertainment use of SNS. As for psychological distress, three aspects are measured in this study, namely depression, anxiety, and stress. Specifically, this study will answer the following research questions:

1. What is the purpose of SNS usage among university students?
2. What is the extent of severity of depression, anxiety, and stress symptoms among university students?

4. Method

This study was conducted using a quantitative method utilizing a descriptive analysis. Using a table of random numbers which comprised numbers that has no order or pattern, the students were randomly selected. A total of 112 participants were randomly selected among the university students from the Faculty of Engineering and the Faculty of Medicine and Health Science in Universiti Putra Malaysia. This study utilized two instruments, specifically the social networking usage questionnaire (SNUQ) developed by Gupta *et al.* (2018), together with the depression, anxiety and stress scale – 21 items (DASS-21) developed by Lovibond *et al.* (1995). By using online survey forms, the questionnaires were dispersed to the participants via email. As shown in Table 1, more than half of the respondents were between 18 to 22 years old, which are 71 (63.40%) of the total respondents.

Table 1. *Distribution of Respondents by Age*

Range	Frequency	Percent
18 – 22	71	63.40
23 – 27	38	33.90
Above 27	3	2.70
Total	112	100.0

5. Main findings

5.1 Purpose of SNS usage

The purpose of SNS usage was measured regarding how frequently the university student used SNS for social, academic, information, and entertainment purposes. The overall mean scores for social, academic, information, and entertainment are 3.60, 3.84, 3.61, and 4.05, respectively. Table 2 shows the students' responses regarding their purpose of using SNS during the prolonged COVID-19 pandemic measured by 17 items. Among the four purposes, university students use SNS most often for entertainment, followed by academic, social, and information. They also used SNS the least for seeking help from lecturers and searching for career-related information.

5.2 Psychological distress

A total of 21 items were used to measure the severity of psychological distress among the university students. Figure 1 illustrates that the percentage of students suffering from depression, anxiety, and stress were 33.5%, 48.5%, and 27.5%, respectively. The university students were most anxious, followed by depression and stress during this prolonged global crisis.

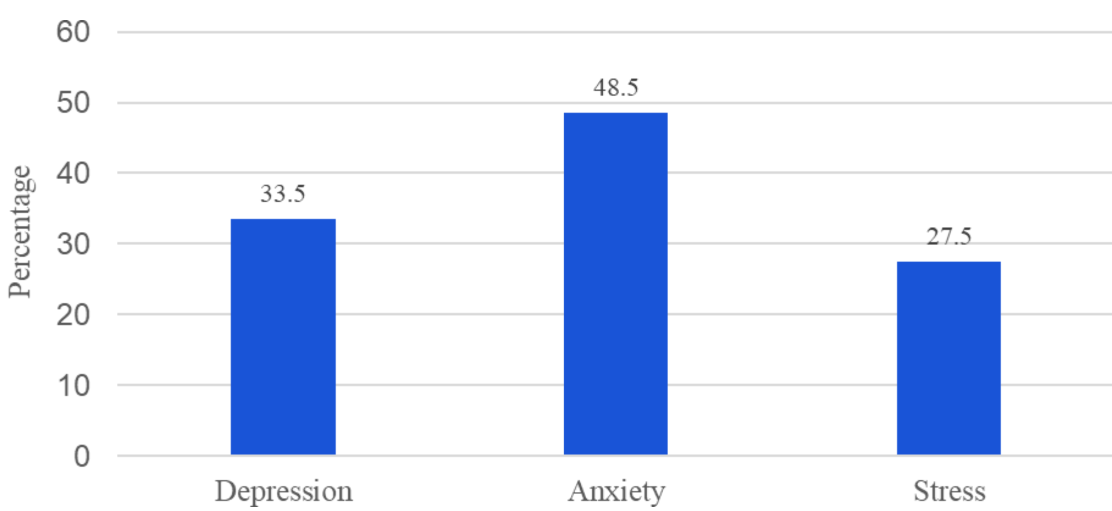

Figure 1. Percentage of Severe to Extremely Severe Psychological Distress

Table 2. *Frequency and Percentage of SNS Usage*

Items		Never		Rarely		Sometimes		Often		Always	
		f	%	f	%	f	%	f	%	f	%
1.	I use social networking sites to become more sociable.[a]	14	6.6	30	14.2	47	22.2	57	26.9	64	30.2
2.	I use social networking sites to keep in touch with my relatives. [a]	11	5.2	33	15.6	46	21.7	49	23.1	73	34.4
3.	I prefer using social networking sites to attend social gathering. [a]	22	10.4	31	14.5	43	20.3	42	19.8	74	34.9
4.	I use social networking sites to seek help from my lecturers. [b]	13	6.1	41	19.3	57	26.9	57	26.9	44	20.8
5.	I use social networking sites for online academic group discussion. [b]	5	2.4	14	6.6	40	18.9	62	29.2	91	42.9
6.	I use social networking sites to do research work. [b]	8	3.8	27	12.7	35	16.5	48	22.6	94	44.3
7.	I use social networking sites to learn about my curricular aspect. [b]	6	2.8	25	11.8	54	25.5	56	26.4	71	33.5
8.	I communicate with my friends via social networking sites for preparation of exam. [b]	14	6.6	17	8.0	40	18.9	59	27.8	82	38.7
9.	I use social networking sites for collaborative learning. [b]	12	5.7	18	8.5	54	25.5	57	26.9	71	33.5
10.	I use social networking sites to solve my academic problem. [b]	5	2.4	18	8.5	35	16.5	61	28.8	93	43.9
11.	I use social networking sites for getting jobs related information. [c]	9	4.2	40	18.9	58	27.4	51	24.1	54	25.5
12.	I use social networking sites to share new ideas. [c]	12	5.7	39	18.4	53	25.0	48	22.6	60	28.3
13.	I use social networking sites for reading news. [c]	6	2.8	24	11.3	52	24.5	55	25.9	75	35.4
14.	I use social networking sites for sharing pictures. [d]	7	3.3	38	17.9	40	18.9	41	19.3	86	40.6
15.	I use social networking sites to get relief from academic stress. [d]	3	1.4	12	5.7	23	10.8	54	25.5	120	56.6

16.	I use social networking sites for watching movies. [d]	9	4.2	15	7.1	29	13.7	48	22.6	111	52.4
17.	I use social networking sites to look at humorous posts. [d]	9	4.2	22	10.4	34	16.0	46	21.7	101	47.6

Notes: [a] Social purpose, [b] academic purpose, [c] information purpose, [d] entertainment purpose.

6. Discussion

This study aims to determine the purpose of using SNS among university students and the severity of their psychological distress due to the prolonged COVID-19 pandemic. This study has found that most students spend a large portion of their time using SNS. The high mean scores shown in all four purposes indicate that the students actively use SNS as an alternative in terms of social, academic, information, and entertainment when physical events are prohibited, mainly for entertainment purposes. MCMC (2020) and Al-Dwaikat *et al.*, (2020) also had similar findings when studying the SNS usage of university students during the epidemic.

Intriguingly, this study showed that the students use SNS least to seek lecturers' help. This infers that the students prefer reaching out to their peers or working independently when solving academic problems; it also suggests that students and lecturers are not accustomed to communicating online; either party may prefer interacting in person. This study also showed that the students seldom use SNS to search for career-related information. This might be because, as most of the participants in this study are in their early years of university studies, career prospects are a lower priority than excelling in their academic achievements.

This study's findings have shown that many students suffer from acute depression, anxiety, and stress regarding the psychological distress of university students. Almost half of the students reported severe to extremely severe anxiety, which is worse than the findings presented by Sundarasen *et al.* (2020) and Cao *et al.* (2020). Around one-third of the students underwent severe to extremely severe depression and stress, which is incongruent with what was concluded by Sandhya (2021) and AlDwaikat *et al.* (2020). This can be caused by the accumulated negative emotions due to the fear of being infected by the new COVID-19 variants such as the Omicron variant, the challenges they faced in confronting learning loss, uncertainties in their future, together with readapting to the new normal. It is evident that the psychological distress among university students has been exacerbated during this prolonged pandemic.

7. Conclusion

This study found that university students are still avid users of SNS even when lockdown has been lifted. They use SNS primarily for entertainment, academic, social and information purposes. This suggests that SNS can be a powerful educational tool in implementing instructions even after the pandemic. With SNS, students' engagement can be transcended from the traditional brick-and-mortar instruction to not only a social experience but also ubiquitous. When students are more engaged in lessons and connected to their peers, their learning can become more concrete.

However, the already pertinent issue of psychological distress among university students has become more alarming than ever during this challenging time. This is a wake-up call for all educational stakeholders like policymakers, institutions, and parents to address mental health issues among the students before more of them submit themselves to addictions such as alcoholism and drugs, or even worse, self-harm and suicide. It is recommended that future studies can be carried out to examine the relationship between the purpose of SNS usage and psychological distress, as well as whether the variables predict one another.

8. Limitations of the study

One of the limitations of this study is that the data were collected via only a self-reporting questionnaire; such responses are prone to response bias, response sets, and response style (Fraenkel *et al.*, 2011). The data collected were based solely on the participants' honesty and perception of their SNS usage and psychological distress. This can be complemented with qualitative data collected through interviews and ethnography studies. Also, as the participants of this study are university students from two faculties in

Universiti Putra Malaysia, the generalizability of the findings in this study can be further expanded by having a larger number of participants from more diverse backgrounds.

9. Implications of the study

This study implies that educational stakeholders and policymakers should consider integrating SNS in teaching and learning to enhance students' engagement. The lower SNS usage for contacting lecturers indicates that students' feedback on their preference for using SNS in learning must be considered. This provides a student-centred plan that can enable the integration of SNS more effective. This study also indicates that mental health monitoring systems and support must be accessible to the students in institutions. This is because the results from this study have shown that many students are struggling emotionally. Mental health professionals like psychiatrists and counsellors should be placed in the institutions, and simple guidelines should be provided to the students so that those in need would know how to seek emotional support.

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Identifying the Supports to Foster Teachers' Development of Learning Design Practices

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Abstract: In traditional classrooms worldwide, one of the most common strategies is lecturing, sometimes with the help of technology tools. An important barrier to the effective integration of information and communication technologies (ICT) has been identified to be the inability of teachers in creating effective student-centered learning designs. To foster teachers' learning design practices, there is a need to understand the supports that teachers need. In this study, we conducted teacher interviews to identify the types of supports that teachers need for designing effective student-centered learning designs within their context. Our findings convey that teachers need learning design support towards creation, contextualization and collaboration. These findings may stimulate momentum for further attention to researchers involved with learning design frameworks and tools development.

Keywords: Learning Design, ICT integration, lesson planning, design thinking, teacher education, learning design tool, teacher needs, technology enhanced learning

1. Introduction

Learning design (LD) is a complex and integrated process, which includes different stages i.e., planning, designing, orchestrating, and running sequences of teaching and learning activities (Dobozy & Cameron, 2018). School teachers are reported to have difficulty in designing learner-centric learning designs (LDs) with ICT integration. Tsai & Chai (2012) argue that teachers' lack of design thinking is the crucial "third-order barrier" to technology integration. Hence, we need to focus on enhancing teachers' design thinking skills. Design thinking is defined as the 'dynamic creation of knowledge and practice' by the teachers in response to the pedagogical affordances provided by the ICT tools (Tsai & Chai, 2012). As classroom context and students are dynamic, the teacher should rely on design thinking to re-organise or create learning materials and activities, adapting to the instructional needs of different contexts or varying groups of learners. However, the enhancement of design thinking for teachers is not a significant component of typical teacher education programs.

Learning design has emerged as an important issue with research and development work focused on ways in which teachers can be supported to design learning experiences for students. Aiming to support teachers to represent their teaching ideas, a variety of strategies have been implemented, such as learning design tools that attempt to provide designers with some form of guidance and support around their design practice (Conole & Willis, 2013), training programs and workshops (Persico and Pozzi, 2013), community-based platforms to share knowledge (Prieto, et al., 2014) and so on. Yet there is an incomplete understanding behind the lack of adoption of studentcentered learning design practices (Mor & Mogilevsky, 2013; Prieto et al., 2014; Boloudakis, Retalis & Psaromiligkos, 2018; Mor et al., 2013). To find suitable ways to foster school teachers' development of learning design practice, there is a need for further research to identify the supports teachers require in designing effective learner centric LDs in their context.

2. Background and Literature Review

Reviews related to barriers to ICT integration in the classroom reported that there are three types of barriers (Dexter et al. 2002; Ertmer 1999; Judson 2006). The first-order barriers are external to the teacher (resources, institutions, subject culture, and assessment) and two second-order barriers are internal to teachers (teacher attitudes and beliefs, and knowledge and skills). First-order barriers wereseen as less significant than second-order ones. As academic researchers, first-order barriers are often not in our hands. In recent decades, much research has been done on second-order barriers, which has led to exploring several dimensions associated with teacher attitudes, beliefs, knowledge, and skills. Tsai & Chang (2012) observes that teachers' lack of design thinking has been identified as an essential barrier i.e., "third-order barrier" for technology integration. "It is essential to have teachers see the value of design thinking in their classrooms, and the connection between design and the academic goals of the classroom needed" (Carroll et al., 2010). Thus, the broad problem is related to the ineffectiveness of ICT integration by teachers. This is due to their inability to design effective teaching-learning activities with ICT. This preliminary study was designed to understand the support that teachers require so that they may design effective LDs.

Multiple solutions have been developed to address the issue of the lack of design thinking among teachers. These include teachers training programs and workshops (Lakkala & Ilomäki, 2015), online portals for sharing best practices (Shaffer et al., 2011), teaching frameworks and guidelines (Biggs, 1996; Howland et al., 2012; Sorva, Karavirta, & Malmi, 2013), and learning design frameworks (Conole, 2014; Laurillard, 2013) and tools (Laurillard, 2012; Lukasiak et al., 2005). Such workshops have been reported to be insufficient in improving teachers' ability to design effective LDs (Conole & Alevizou, 2010).

Celik & Magoulas (2016) conducted a literature review on teachers' perceptions, practices, and needs of LD tools, yet there is limited understanding of teachers' perceptions of these tools and of their design practices while using them. There is also no clear understanding of the reasons behind the lack of adoption of LD tools among teachers (Mor & Mogilevsky, 2013; Boloudakis, Retalis & Psaromiligkos, 2018) or of the platform features that could mostly appeal to the teacher community (Prieto, et al., 2014). LD tools have been developed to provide computer-aided support to the LD process, aiming to make pedagogical decisions explicit and provide computer-interpretable visualization/representations of the designs (Prieto, et al., 2014). Although teacher training acknowledges that pre-service and novice teachers should be trained in LD approaches (Persico and Pozzi, 2013), the way LD tools can be incorporated in their training to support the development of a common understanding of LD issues remains a challenging problem (Papanikolaou, Makri and Roussos, 2017). For example, teachers find it difficult to translate theory into practice (Laurillard, 2012) or customize best practices for their own context (Schaffer et al., 2011). However, for our solution to be relevant to our target users, we needed to analyze the problem in our research context and identify where in the LD creation process teachers needed support.

Bennett et al. (2015) explored the support that helped university teachers' in their design processes. They identified teachers' perceptions of their student characteristics, their own beliefs and experiences about teaching and learning, and contextual factors as crucial influences on design decisions. They also suggested other supports like improving teachers' knowledge of students, sharing practices, providing guidance about pedagogical theory, and enabling flexibility in design processes and within designs themselves. Support tools have the most potential in improving design decisions by engaging with these crucial influences that shape existing design practices. In the same line, Arpetti, Baranauskas & Leo (2014) explored as needs or in the form of requirements by the teachers themselves regarding learning design practices and representations. The result revealed that support for reflection, considering educational needs of learners, ease of use, economy in terms of time, reuse of designs and support to design were the most important, sharing of designs practice was as neutral, whereas software compatibility, graphical representation of designs, collaboration, author identification, aesthetics (look and feel of the software) meant to be less important requirements for teachers for learning design.

Conole (2014) explored the support for teachers that were derived from the evaluation of learning design tools. Flexibility is found to be a desirable feature for adapting designs to different educational contexts and teachers showed as a positive aspect in the evaluation of an LD tool, Support for reuse and adaptation of designs practice seems to be preferred to the creation of new designs. Usability is one of the most commonly valued parameters in the evaluation studies. Textual representation of designs is valued by teachers when this aspect is explored during the evaluation of a tool.

Dagnino et al. (2018) conducted a systematic review where they identified and categorized different types of support that teachers require for different learning designs. The categories of teachers' needs were as follows : Flexibility in terms of reuse of designs and their revision and adaptation to educational needs and also in the design process but, at the same time, provide guidance; Support theretrieval of existing designs and mediate their adaptation; Support for co-operation amongst teachers in terms of a peer evaluation and to share one's own design for commenting or collaborative editing; Support for reflection by providing the design in graphical or textual format in every moment during and after the design phase; Ease of use ranging from easily fillable templates for teachers without having technical skills; economy in terms of time; Textual and graphical representation and Activate design thinking processes teachers are familiar with based on the teachers' and institutional design culture.

This review of literature and analysis of LD tools helped us identify different supports. These categories of supports would be used to help our coding in the research studies within Indian contexts.

3. Methodology

The research question that we investigate in this study is: *What supports do teachers require for designing effective learner-centric LDs while integrating ICT in the classroom?*

This study used a qualitative approach where we conducted a needs analysis of teachers via interviews. Thematic analysis was done for analysis of the interviews data.

3.1 Participants and Data Collection

This study began in late 2021 and the target population for this study was pre-service and in-service secondary level teachers from different types of schools (government, government aided-private, and unaided-private) in Delhi, who use ICT in their teaching learning. The exact target audience for the study is yet to be decided. The participants for this study were chosen based on the convenient sampling. Teachers from different schools of the Delhi region in this study were contacted through email and phone calls. Data collection included semi-structured interviews which including teacher reflections or experiences. We selected teachers, who showed interest in participating in the study. The study is ongoing and so far we have interviewed 6 teachers, 3 in-services and 3 pre-service out of 4 male and 2 female participants. Their academic disciplines were from sciences, social science, mathematics, languages. The majority, 83.33%, had not used any learning design tool before the study, while 16.66% had. Our plan for the study is to interview 10-15 more teachers.

We conducted semi-structured interviews with the participants. The interview protocol was designed in such a way to elicit the challenges faced by teachers in learning design through experiences of the teachers. We also tried to understand teachers' support required for designing effective learnercentric learning design while ICT integration in the Indian classroom. Interviews were conducted over the GMeet platform in the English and Hindi language and took approximately 1 hour. Follow up clarifications were sought via phone calls. All interviews were videotaped for further analysis. Personally identifiable data were anonymized immediately after data collection. Sample interview questions included:

- How do you develop lesson plans?
- What problems did you face in lesson planning for the class?
- Do you collaborate at any point of planning – do you co-create or share or both? If not, why?
- Have you reflected over your lesson plan? Explain any instance when you reflected on your lesson plan? How do you reflect on your own lesson?
- How much of your pre-service training helped you in creating learning designs? Where did you struggle more? Have you found a solution?

3.2 Data Analysis

The recorded interviews audio responses were transcribed into verbatim in English text with the help of an online meeting transcriber. Additionally, the transcribed non-English text was translated into English for further analysis. Thematic analysis (Braun & Clarke, 2012) was used as a 'coding frame' for structuring transcribed data. Data analysis involved identification of themes related to support that teachers require for designing effective learner-centric LDs while ICT integration. This was followed by familiarizing with the data and generating initial codes. Firstly, the collected data were coded, edited, consolidated, and entered into a master sheet. During this phase, the highlighting of the phrases andsentences were done and then the themes were named and defined. The data collected from the respondents were coded based on the themes and analyzed the data based on them.

4. Findings

From the thematic analysis, eight themes were identified as follows:

- *Templates / Prompts:* Learning designs provided with prompts that can be easily filled by teachers without specific technical skills.
- *Basket of strategies:* Learning designs that were provided must have sets/samples of lessons on the same topic with different strategies.
- *Review/ Comparison mechanism:* Existing learning designs provided that help in building new learning designs or reviewing new designs.
- *Reusability:* Learning designs that were provided were readily understood, adapted and reused by teachers in their context. Teachers were able to effectively adapt and reuse previously documented learning designs according to their own needs.
- *Understanding students' needs:* Learning designs must cater to the needs of the learners.
- *Relatable examples/content in context:* Learning designs must provide specific examples that are related to the context of the learners.
- *Expert/Mentor support:* Learning designs must provide a mechanism for expert feedback.
- *Peer-support:* Learning designs were created with support of peers like collaborating to create new designs or to review designs of their peers.

There were patterns of themes, so we grouped into categories based on the similarities. The three categories emerged as: creation, contextualization, and collaboration in Table 1.

Table 1. *Details of themes emerged from empirical evidences*

Categories	**Themes**	**Illustrative evidence**
Creation	1. Templates / Prompts 2. Basket of strategies 3. Review/Comparison mechanism 4. Reusability	**Teacher 4:** "Every *day we have to make at least two lesson plans and for the same lessons we have to make teaching learning material also, this process is so tedious for us. So we want something like ready to use templates that we customize for us."* ***Teacher 5:*** *"Sometimes we feel whatever we prepare for class, it does not work. So, we think that we can make different lesson plans for the same topic by using different strategies. But it is not possible on a regular basis.* ***Teacher 6:*** *"During teaching practice, the mentor asked us to prepare a lesson on a particular topic and then provide one standard lesson to us to review/compare our own lesson that help in designing our lesson in more effective way"* **Teacher 1: "***Our mentors provide some standard templates of lesson plan or itself lesson plan for our reference"*
Contextualization	5. Understanding students' needs 6. Relatable examples/ Content in Context	**Teacher 2:** *"We have already designed lesson plans from the past year, but when we go to school we find students with different backgrounds and the lesson plan does not seem to fulfill the needs of different students. So sometimes we use the lesson plan as it is or refine it and use it according to the students' needs."* **Teacher 5:** *"Sometimes our mentor suggests using lesson plans that are made by our seniors that are available in the department. But it does not fit our students like there is no coherence between two lesson plans, examples are not fitted*
		in my lesson plan."
Collaboration	7. Expert/ Mentor support 8. Peer- support	**Teacher 3:** *"We are just trainee teachers; we feel that whatever lessons we make are novice. So we feel that either experts / mentors will review it before teaching into the actual classroom. Based on their feedback we can modify our lesson and perform better in the classroom."* **Teacher 4:** "*During micro-teaching practice, our peers also review lesson plans that build our confidence."*

5. Discussion

This paper describes a study on needs analysis of teachers to address the supports that teachers need while designing learner-centric LDs. The study conducted among school teachers in Delhi, India has shown a different range of supports required by the teachers in designing effective learner-centric LDs. We have found that teachers require ample support towards creation, contextualization of the LDs and also provinces for effective collaboration in LDs creation.

The findings of this study align with previous research on teacher support required for the creation of LDs. A study by Dagnino (2018) asserts that teachers need ready-to-use design templates and flexibility in terms of pedagogical choices in structuring a learning design. In our study, the teachers stated the requirement of the availability of different templates aligned with the pedagogical goals of the particular lesson for the teachers to choose from. The teachers also demonstrated the need to be prompted in learning design that can be easily filled by teachers without specific technical skills. Moreover, our teachers needed support that could enable them to effectively select, apply and adapt previously documented learning designs according to their own needs.

Teachers in our study were open to support required in terms of conceptualizing and applying the learners' context. Notably, some teachers spoke about approaching learning design by considering students' needs, interests and tailor the resources and the activities around their interests or their motivations. Such efforts to 'get to know' students are reported to be a consistent theme in the study conducted by Bennett et.al (2015) wherein teachers built up a profile of their students over time and identified the needs of their students by their perceived characteristics and their academic performance. This information influenced how teachers designed their lessons and how they adapted those designs to suit the evolving profiles of their students. According to Agostinho et.al (2013), the contextualized description was deemed as a useful support in the design process. Bennett et al (2004) suggest that the contextual detail included in a learning design adds to its reusability.

With respect to support for collaboration, a majority of teachers in our study mentioned that mentor feedback often prompted them to rethink particular areas of their design. In addition, teachers reflect and redesign or refine their designs over time. Their feedback gives probably as many ideas about how to adjust and change and adapt their design. Similarly, in the study conducted by Agostinho et. al (2013), learning designs can be seen as a way to generate and inspire ideas and provide models of good practice against which teachers can compare their own design thinking and work. Comparing the design ideas of teachers' work against their chosen learning design provided teachers with an indication of 'quality' of their designs and some participants reported this comparison gave them more confidence in teachers' abilities and knowledge as a designer. In the study by Dagnino et al (2018), the opportunity to obtain a peer evaluation of a developed LD creation was positively considered by the teachers.

The findings from this study contribute to expanding the support required for designing learner-centric LDs. These findings have implications to researchers working on learning design with integration of technology in the classroom and teacher professional development. This study's context also reports the trajectory to develop rich learning design experience to Indian teachers.

The limitations of this study include the small sample of participants, the limited insights provided by the open-ended question, and there is no utilization of any learning design tool. Our current study did not evaluate any tool. Also, it may yield ample insights if, analysis of support for LDs creation provided by evaluating existing learning design tools. Moreover, provide comprehensive understanding of support required by teachers for LDs creation may develop if qualitative data and quantitative data both included. A future research design may provide participants with a richer design experience if digital learning design tools are used.

6. Conclusion

Supporting teachers to represent their teaching ideas into design has attracted researchers' interest in developing learning design tools that provide some form of guidance around the design practice. This paper reports on a study in a teacher education context as fostering learning design practices. Our work involves investigating the support that teachers' needs for learning design to achieve an overall perspective of teachers' needs during the learning design process.

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Evidence Over Intuition: Identifying Factors That Influence the Effectiveness of Large Scale Edtech Initiatives

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Abstract: We analyze four EdTech initiatives in India to identify relevant factors that determine their effectiveness. We use a two-fold data analysis technique to first comparatively analyze these EdTech interventions and then use a broader theoretical framework to further probe the identified factors. This study reveals that the primary factors involved in effective implementation of EdTech initiatives are: learners' interest in the device and content, the support provided by teachers and mentors, the interest shown by the learners' own community, the functionality and a provision for maintenance of the devices, the mode of implementation, availability of appropriate pedagogical and technical support, the socio-cultural-economic background of the learners, and cost, scalability and sustainability of the initiative.

Keywords: EdTech Initiatives, Large Scale Initiatives, Indian context

1. Introduction

In recent years, many developing countries have been expanding their education systems which has created an additional stress resulting in lags in learning, retention, graduation rates, and socioeconomic equity. Investments in educational technology (EdTech), are seen as a possible way to improve these outcomes. However, in some cases, these EdTech projects fall short of delivering their intended effects or in other cases their effects are not long-term. One reason for this is they do not have sound empirical support. There is a need to go beyond intuitive ideas and move in the direction of empirical research-based guidelines for EdTech interventions.

In the developing countries, EdTech boom has created the need for governments to regulate this sector so that fair practices and standards can be implemented. This regulation will be based on research-based guidelines about effective use of educational technology. Hence, a rigorous study of EdTech initiatives is needed to understand their adoption and integration which can inform what factors might influence effective or ineffective interventions. The goal of this paper is to identify a list of essential factors that must be accounted for while designing an EdTech intervention, particularly in the context of developing countries like India.

In developed countries, a fair amount of research has been conducted to identify factors responsible for effective implementation of EdTech initiatives. However, there exist limited studies in the context of developing countries, and they mostly analyze a particular initiative to understand the factors. Rodriguez-Segura (2021) has conducted a literature review of EdTech in developing countries and has categorized the initiatives under four broad themes: access to technology, technology-enabled behavioral interventions, improvements to instruction and self-led learning. He analyzes these programs in terms of their intended policy targets, effectiveness, cost-Effectiveness, best uses, potential pitfalls and challenges. A similar literature review was conducted by Keengwe & Malapile (2014) who concluded that the responsible factors were the selling of refurbished computers for use on a large scale, the high prices and low effectiveness of services provided by technology-related multinational corporations in developing countries, the philosophical perspectives and priorities of organizations, foundations, and development agencies promoting the implementation of ICTs in developing countries, and the predominance of the English language in the software.

There exist some relevant studies which have focused on individual EdTech initiatives to arrive at the relevant factors for success and failure. Ezumah (2012) in their study regarding use of the One Laptop Per Child (OLPC) projects in Nigeria and Ghana, claimed that lack of meticulous preparationand implementation of the adoption process prevented the project from achieving its objective. Similarly, in India, Ale, Loh & Chib (2017) had conducted a study to measure the learning and mediation of computer self-efficacy of OLPC project in the rural areas. The findings of their study showed how contextualized technology might be used in rural classrooms together with knowledge of how user psychology affects learning outcomes. Another study by Karunaratne, Peiris & Hansson (2018) in a different setting argued that the main challenges in implementation of smallscale ICT projects in developing countries were the usual technical and infrastructural restrictions.

The current paper focuses on a single country, India, and covers different initiatives within it. This method can provide rich data on country specific factors which can inform the contextualization issue in EdTech in developing countries. This alternative approach has the potential of being used as an exemplar to conduct similar studies in various other developing countries. This current paper not only does a comparative analysis of initiatives like previous studies but also uses a theoretical lens to further analyze them. This paper has three primary contributions. The first contribution is moving beyond intuition or a utopian belief about the transformative potential of technology, and instead using empirically available data to plan guidelines for future EdTech initiatives. Second, this analysis is an attempt to shed some light on the unique conditions of the Indian EdTech scene. This can lend weight to the demand for customizing EdTech projects according to local needs. Third, this paper brings together information available in various reports and studies on diverse EdTech initiatives at one single place and attempts to provide an accessible document to get a broader understanding of this phenomenon.

2. EdTech initiatives considered

Four EdTech initiatives out of India were explored and analyzed in this paper: Hole in the Wall Education Limited (HiWEL), Connected Learning Initiative (CLIx), Mindspark and Pratham Digital Initiative (PraDiGi). A purposive sampling technique was used to select these initiatives on the basis that these interventions go beyond information dissemination and provide a blended experience to the learners where the role of technology is to enhance creativity and collaboration. The data for these initiatives was taken from published reports and research papers available in the public domain.

HiWEL aims to provide a fun learning environment for underprivileged children by establishing Playground Computer Learning Stations (50+ kiosks) that operate outside of school boundaries. Arora (2010) in her study of two HiWEL kiosks in the Uttarakhand state of India explored factors that can derail such an initiative.

CLIx is a large-scale, technology-based project for high school students implemented in 478 schools. CLIX team has published reports exploring themes from implementation of the program to its success and community engagement (Connected Learning Initiative, 2020; Mulla, Shende, & Nagarjuna, 2019).

The Abdul Latif Jameel Poverty Action Lab (J-PAL) conducted an evaluation study of the impact of a personalized technology-aided after-school instruction program, Mindpsark, in middleschool grades in urban India (Muralidharan, Singh & Ganimian, 2019).

PraDigi is a digital programme that delivers tablets to rural communities, as well as a learning app that provides children with high-quality, interactive information to help them improve their fundamental reading and numeracy abilities, as well as their capacity to think critically and collaborate (Pratham Education Foundation, n.d.).

3. Findings

A two-fold analysis technique was implemented. Each initiative was analyzed in detail and a concept map was created to identify common features across initiatives. Next, a characterization table was generated to analyze the similarity and differences between these initiatives. These similarities and differences were coupled with broader theoretical frameworks to get a holistic picture.

Table 1 shows the factors identified, the empirical support (the presence/absence of the feature), the resulting outcome and the aligned theoretical frameworks. Each factor is discussed in detail below, from the lens of its contribution to the effective implementation of EdTech initiatives. While the degree of importance of these factors might vary across programs and contexts, they still are prominent enough to be covered while planning any potential initiatives.

Table 1. *Empirical data and theoretical frameworks in data analysis*

Factors	**Empirical Data from Initiatives**				**Theoretical framework**
	Factor is incorporated		**Factor is not incorporated**		
	Feature of program design	*Outcome*	*Feature of program design*	*Outcome*	
Learner interest in the device and content			HiWEL provides access to computer and internet without a set curriculum	Students used the systems for entertainment activities like playing games	Underprivileged children primarily tend to use computers for entertainment (Anthony, & Padmanabha, 2010)
Support provided by teachers or mentors	CLIx incorporated a TPD program	Teachers' advanced digital skills improved significantly	HiWEL did not employ teachers	Children struggled to make optimum learning use of devices	Diverse theories from Behaviorism to Constructivism recommend teacher support (Brau et al., 2022; Mcleod, 2019)
Learners' community interest in the initiative	PraDiGi leaders raise community awareness about their initiative	Expect the community to get involved with the initiative	HiWEL tried to substitute mainstream govt school education	School teachers felt threatened by this initiative	Community Outreach Programs are essential for out-of-school learning (Peppler, 2017)
Functionality and maintenance of the devices			HiWEL expected the community to automatically take over kiosk maintenance	Community showed no interest in maintenance of the kiosks	Theory of preventive maintenance suggests use of periodic maintenance drives (Hyman, 2003)
Mode of implement-ation of the initiative	PraDigi gave personal learning devices to students	Students utilized them in school and out of school			Social constructivism theory views school as a place to facilitate peer learning (Parr & Townsend, 2002)
Availability of pedagogical and technical support	Mindspark had trained staff available at centers to assist the learners	Expects that staff to help and guide the learners			While students maybe digital natives, teachers need support to use edtech in classrooms (Inoa & LoCascio, 2020)
	CLIx technical team visits project locations to provide assistance	Expects this team to solve technical and pedagogical issues			
Socio-economic background of the learner	PraDiGi offered content for home, school & life needs	Expects learners to pick up a socially relevant course			Theory of connected learning embraces the diverse backgrounds and interests of all learners

	CLIx brought in teachers' inputs for course design	Expects teachers' inputs to represent students' expectations			(Connected Learning Alliance, 2018)
Cost, Scalability and Sustainability	CLIx works with government institutes	Expects the government machinery to sustain work in the long-term	HiWEL expected the community to financially support the kiosk	Kiosk was closed due to lack of financial support	The equal educational opportunities theory advocates schemes that do not discriminate
of the initiative	Mindspark initially offered their service free of cost	Students only attended the program while it was free			between groups of people (Amos & Abdul Kareem, 2013)

Factor 1: Learner interest in the device and content

The HiWEL initiative did not consider learner preference when designing the program. It provided free access to internet and computers without a set curriculum which resulted in the students using the systems for entertainment activities like playing games. Reports from other initiatives also suggest that learners from a disadvantaged socio-economic background may primarily use digital devices for entertainment and media consumption (Anthony & Padmanabhan, 2010). The CLIx program used a co-design approach, bringing in teachers' inputs for designing of the teaching-learning material, with the assumption that students' interest will be appropriately conveyed by teachers.

Factor 2: Need for teacher/mentor support

HiWEL did not employ teachers as they believed in minimal invasive education, this resulted in children struggling to make optimum learning use of devices (Arora, 2010). This means that just providing hardware is not enough, at least if the goal is to go beyond basic digital skills. Learning has to be supported and facilitated by competent mentors. In order to ensure effective teacher support, CLIx incorporates Teacher Professional Development (TPD) as part of their intervention. This TPD program has resulted in teachers' advanced digital skills improving significantly and behaviors aligned with CLIx pedagogic pillars being more evident. The need for teacher support is supported by contemporary learning theories, ranging from behaviorism to constructivism (Brau et al., 2022; Mcleod, 2019).

Factor 3: Developing community interest in the initiative

The HiWEL program in Uttarakhand initially projected their initiative as an alternative to the poor quality of learning that took place in government schools. The local teachers felt threatened in terms of their own role in education and developed antipathy for the initiative. On the other hand, PraDiGi engaged with the community to raise awareness and bring a sense of ownership. This sense of ownership can possibly engage a community in such a way that they accept an initiative as their own and support it in the long term. This need for community connection is also substantiated by the practice of Community Outreach Programs as part of out-of-school learning projects (Peppler, 2017).

Factor 4: Functionality and maintenance of the devices

HiWEL computer kiosks in the Hawalbagh region of Uttarakhand (India) had to be shut down after a short period because of lack of support. The HiWEL organization had expected the community to bear the expenses of the computer kiosk after an initial period of hand-holding. However, the community on the other hand still expected HiWEL to continue supporting their initiative. Even CLIx struggled with their ICT Lab infrastructure in Telangana as some of the ICT infrastructure was not optimally functional. This means that devices which are part of an EdTech initiative have to be maintained and repaired regularly. The theory of preventive maintenance suggests use of periodic maintenance drives to ensure the proper functioning of project equipment (Hyman, 2003).

Factor 5: Mode of implementation

The J-Pal study commented that Mindspark might have yielded different results if it was an in-school program as compared to an after-school program. HiWEL initially opened out of class computer kiosks but finally, they turned to schools for foundational technical training of the children and also to provide a safe space for the kiosks. CLIx decided to work with government schools to ensure sustainability, so the intervention can stay functional on its own. While Pratham did not work with schools, it did offer the learning content to prepare students for school life. Therefore, the success of an initiative is dependent on how they engage with the local school system, whether it tries to work with the schools or substitute them. Social constructivism theory places a significant emphasis on in-school education as it provides an opportunity for peer learning and collaboration (Parr & Townsend, 2002).

Factor 6: Availability of pedagogical and technical support

With the HiWEL initiative, the school teachers mostly perceived the kiosks as a distraction as the students spent their time playing games or consuming entertainment media at the kiosks. This could have been changed if instructors were available at the kiosks to guide the students in terms of their pedagogical and technical knowledge. The J-PAL evaluation proposed that Mindspark staff should be present at the centers for assistance of the learners. Similarly, CLIx has a provision for technical staff present on the ground to assist the initiative. The use of technology for learning can also create a technical barrier in terms of the ability to use the technology, hence it is important to provide appropriate pedagogical and technical support. Inoa & LoCascio (2020) advise that while students may be digital natives, teachers need support to use edtech in classrooms.

Factor 7: Socio-cultural-economic background of the learner

The designers of HiWEL initiative made an assumption that peer-learning is inherently beneficial. They believed that learners at a kiosk would help each other figure out how to use a computer. However, they failed to incorporate the fact that learners brought their own biases to the program, and this resulted in discrimination at the kiosks. There were cases of bullying at the kiosks, and it was mostly boys who would visit these kiosks (Arora, 2010). Therefore, it becomes essential that the socio-cultural background of the learners needs to be accounted for while designing an intervention. In the case of PraDiGi, they worked in a rural setting and so they had to accept the fact that many learners might prefer to also work in order to sustain their families, so they offered the learner a choice to pick courses which are relevant to their socio-economic needs. The need to cater to the socioeconomic differences of learners is supported by the theory of connected learning that embraces the diverse backgrounds and interests of all learners (Connected Learning Alliance, 2018).

Factor 8: Cost, Scalability and Sustainability of the initiative

Students attended the Mindspark centres only till it was free. Similarly, HiWEL expected the community to take over the maintenance cost of the kiosks after a period of hand-holding but the community showed no interest and the kiosk had to be shut down. Even if the cost of initiatives might seem meager, it becomes financially unsustainable in a country like India with considerable income inequality. Therefore, as per egalitarian principles, cost-effective or state subsidized initiatives are better suited in such communities. This argument is supported by the equal educational opportunity theory, which advocates schemes that do not discriminate between groups of people (Amos & AbdulKareem, 2013). In terms of sustainability, initiatives like CLIx, Mindspark and HiWEL ensure that the same devices can be used by successive batches of learners. PraDiGi, while employing personally owned devices, has the option to collect and redistribute the tablets once a group of learners have met their learning goals.

4. Discussion

In order to use a broader lens to understand the four chosen initiatives, the authors also studied some EdTech initiatives from similar developing countries, particularly: One Laptop Per Child (OLPC), EdTech Hub and Digital Youth Network (DYN). OLPC was a non-profit organization which designed and distributed educational devices, along with software and content, for the developing world. OLPC did not make it a priority to account for learner preference when designing the program and its contents. As a result, a majority of the children either found the laptops of no use or they showed no interest in the learning content offered by the laptop (Ames, 2019). This strengthens Factor 1, learners' interest in the initiative. Another global initiative, EdTech Hub uses Sandboxes to make sense of the enabling environment for an initiative. In its Pakistan Sandbox, it was working to improve distance education for deaf learners (EdTech Hub, 2021). Researchers initially offered recorded lectures but then also incorporated live lectures over video call to make the learning experience more interactive. This supports Factor 2, provision of support by teachers/mentors. The final global initiative considered was DYN, a program that aims to assist economically disadvantaged adolescents in developing technical, creative, and analytical abilities (Barron, et al., 2010). The DYN initiative had the goal to create an equal platform for all members of an urban minority community to be digitally literate. DYN used the socio-economic background of the learners as an anchor for the learning activities to which students felt a connection and hence participated actively. Thus Factor 7, the socio-cultural-economic background of the learner needs to be taken into consideration while designing an EdTech intervention.

This paper has analyzed data from studies in India and has substantiated it by adding perspectives from studies of global initiatives, thus providing an empirical basis to the identified factors. The paper also explores challenges of edtech initiatives in a country like India with limited infrastructure and considerable economic disparities. India being a diverse country also needs initiatives that can be customized to local needs. Finally, this paper has synthesized data from multiple individual studies and has coupled it with broader theoretical frameworks to provide a broader understanding of the edtech initiative phenomenon.

Limitations of this paper include the consideration of only those initiatives which have both a virtual and physical element, so it has left out MOOC based initiatives. The paper has also used a purposive sampling technique which reduces its repeatability and generalizability. The small sample size of the initiatives selected limits the amount of empirical data available to corroborate the factors identified. The study is also limited by its reliance on secondary data for analysis, which even though common across such broad studies, limits understanding at ground level. Therefore, future research can be conducted at the site of an ongoing edtech initiative to substantiate the identified factors.

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Interactive Analysis of Children's Video Game Products

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Abstract: Much prior research has advanced the theory of learning based on games in light of the industry's economic prosperity. This paper examines how interactive video games for young children have evolved. Video games have long been a topic of debate in discussions about how children develop, although the effects of playing them remain ambiguous. One drawback of earlier research is that it frequently concentrates on adults' and school students' game-based learning. Young children will inevitably enter the realm of video game education, given the prevalence of smartphones. This study examines how game interaction is played in the market for children's video games while attempting to combine the theory of children's learning and cognition. The analysis model is made to map the software's interaction structure. Then, a comparison and overview of issues in the markets for children's video game software will occur. We found that building interactive systems for video game interfaces takes into account a wider variety of real-life interactions. By establishing the approach of interactive evaluation of children's video games, we hope to bring fresh perspectives to the future development of children's video games.

Keywords: Child Development, Video games, Interactive design

1. Introduction

When a human's material requirements are met mainly, they begin to engage in games, which, along with work, make up daily life (Sailer et al., 2017). Games have their roots in real-world business and military training (Harteveld, 2011; Farah, 2021). The essence of a video game, in contrast to other games, is the player's involvement with an intangible, underlying experience whose physical characteristics are, at best, a means of addressing it (Ghamari-Tabrizi, 2000). The connection between the player and the physical medium is the essence of most games (Pérez & Sánchez Coterón, 2013).

Invariably, the game's core controls its outcome rather than its side effects (Fabricatore, 2007). In the design of video games, it is not the design of the game's look, interface, or special effects that s most important. The video game's vital core is the interaction structure's design (Pinelle & Wong, 2008); (Dickey, 2006). This paper is dedicated to the study of whether the design of interaction structures in the interaction design of video games is humane and appropriate to children's developmental levels.

Successful game design must go beyond intuitive judgment and rash behavior (Tinghög et al., 2016). This is because the designers must follow specific design process guidelines. Only by unifying the design guidelines of a game can a flexible development practice be based on them. A game's design may only be flexibly developed if it is based on (Takeuchi & Nonaka, 1986; Breuer & Bente, 2010). The study's findings indicate that children's development is favorably impacted by number play (Blumberg et al., 2019). The basic design guidelines pursued in this study are to respect children's developmental patterns and cognitive levels.

2. Review of empirical evidence

Our perspective is empirical. It connects early childhood learning theories to video game theory. The results imply that playing video games may enhance various cognitive and psychomotor functions. Close and long-distance transfers from video games to outside chores happen if they play video games (Tobias et al., 2014). Learning is the process of transferring knowledge from the outside to the inside, claim O'Dell and Grayson (1998). To identify appropriate criteria for children's video games, we attempt to assess a child's video game product and can begin with empirical evidence. Research by Coleman and Money (2020) demonstrates that without comprehension of the instructional components in games Without knowing the game's educational components and the student's current learning environment, it is challenging to assess the entire usefulness of digital games. The distinctiveness of game-based learning is difficult to identify on an epistemic level, as is evident from a brief assessment of existing games. Behaviorist, cognitivist, and constructivist components are all used by game designers. Video games are frequently offered in several configurations (Plass et al., 2015).

Children have learning chances thanks to games. At a deeper level, they take in knowledge from numerous sources and act rapidly. Do not even request for the rules; infer them from the game. Cooperate with others more (Hussein et al., 2019). According to Spires (2015), game-based learning involves more than just creating games for students to play; it also entails creating interactive learning activities that may gradually introduce concepts and guide them toward their intended outcomes. The use of games in education is called game-based learning (Pivec, 2009). Students can interact with instructional resources and disciplines in a dynamic, entertaining, and gamified way because to the motivating psychology inherent in gamified learning (Anastasiadis et al., 2018). We also think that the same approach can be applied to young children.

3. Overview of interaction design research

In accordance with Moore's Three Interaction Types (1989). In this study, we combined video game characteristics with criteria for children's cognitive development. The three types of engagement were altered to behavioral, sensory, and emotional interaction. Although every child has sensory and perceptual abilities from birth, he or she needs engage in interaction to achieve sensory unity (Ayres & Robbins,2005). In light of the above discussion, we should consider the interactive experience of video games from a developmental standpoint for children.

Most studies emphasize human-computer interaction; There is little research examining teacher-student interaction (Blumberg et al., 2019). The three common interaction elements are human, interface, and machine/system. The three most important aspects of user experience design are form, behavior, and content (Helander, 2014). The most crucial part is behavior interaction, namely interaction design (Kreijns et al., 2003). In words, interaction is a behavior. Interaction design is about designing behavior in the user experience. It is concerned with how behavior relates to forming and content. Designers must study the user's knowledge system and personal habits to design products tailored to people's daily work and life habits and the end user. The standard of interaction design is to aim for user experience, to care about user involvement, and to bring about a deeper level of user involvement. The standard for interaction design is to aim for user experience, to care about user engagement, and to aim for a deep, immersive experience for the user, which is currently better done by creating new experiences through narrative and emotional connections. Venn diagrams are used in this study to represent the relationships. As shown in Figure 1. interaction design, as an interdisciplinary cross-discipline, combines many disciplines and ideas.

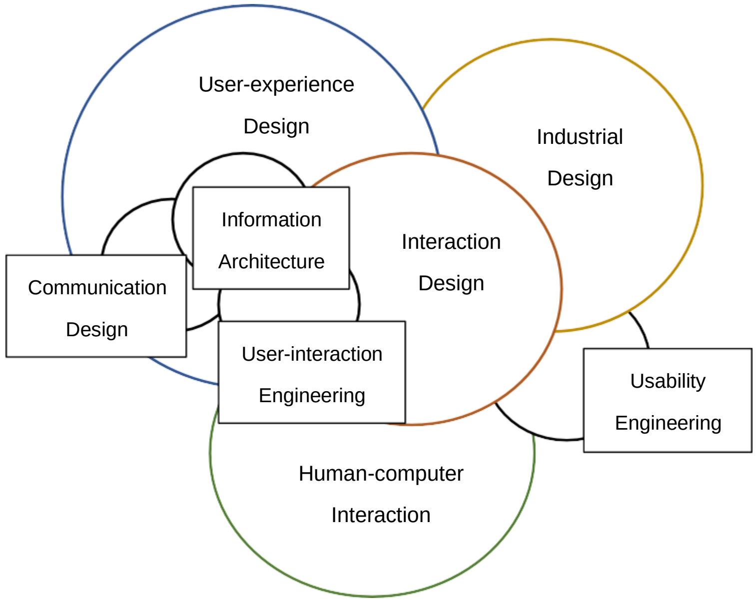


Figure 1. Venn diagram of the interactions design multidisciplinary.

Harsh and Sohail (2002) design research uses a team to manage a series of iterative cycles of educational design, implementation, and evaluation to provide readers with an observation of an adult distance education program in Malaysia. Social constraints and affordances influence conceptual systems and technology. Re-conceptualizing the field of mathematics education research as a design science akin to engineering and other emerging interdisciplinary fields involving the interaction of "subjects" (Lesh & Sriraman, 2005). These methods are examined and reconceptualized through a wide range of academic work. These methods' pedagogical usability reveals their purpose, value, and alignment with the school curriculum (Tzuo, 2012). Yusoff et al. (2018) Review relevant articles on educational games and the role of games as interaction design tools that influence the cognitive, emotional, and social skills students interact with when playing games. Social interaction is the basis for achieving goals. Children's emotional responses to robot-based experiences are expressed in their social behavior toward each other (Caceffo et al., 2022).

4. Overview of the use of children's video game products

Studies show that most school-age children in the United States play video games, computer games, or both (Williams, 2006). The popularity of video games is the highest in Finland, and around 90% of Finnish children play video games regularly (Subrahmanyam & Renukarya, 2015). As of January 2022, according to Statista, there are 107 iOS apps in the Apple App Store alone, with the games category ranked second. YouTube Kids and Facebook Messenger Kids are mobile apps for children found to collect the most data from iOS users worldwide. An analysis of the literature reveals that children's access to video game products is quite common in society, and children's use of digital electronic products for gaming is also commonplace.

Early childhood is the most rapid period of brain development in children. Lin (2008) regards unconscious memory as predominating in early childhood. Anything enjoyable, memorable, and robust to the child is easily remembered. Figurative memory is preferred to logical memory. (Ronald & Mariellen, 1975) also agree with Kohlberg that the moral development of young children is at a pre- customary level and that moral values are judged primarily by external demands. During the developmental stages of childhood, children are exposed to either face-to-face play with peers in the real world or video games in the virtual world. According to Piaget's game stage theory of children's play, the level of space development is commensurate with the child's intellectual development. The emphasis in the design of children's video games is on suitability for children's cognition. The focus is more on the child's experience during the game. The design intention should meet the child's psychological desires and satisfy the child's desire to achieve goals. It should be designed to stimulate the child's interest so that the child can achieve a higher level of self-actualization in the video game rather than simply becoming addicted to it.

5. An analytical framework for children's video games

This study attempted to develop a sound framework for analyzing video games for preschool children. We used a mixed-methods approach to analyze the framework-building process, and our analysis was theory-driven and bottom-up. We attempted to build and integrate with the play research literature in game design by reviewing several game analysis systems and conducting participatory observations and interventions.

First-level analysis structure: The structure of the relationship between input and output in children's video games, mainly between children and mobile application products, is illustrated in Figure 2.

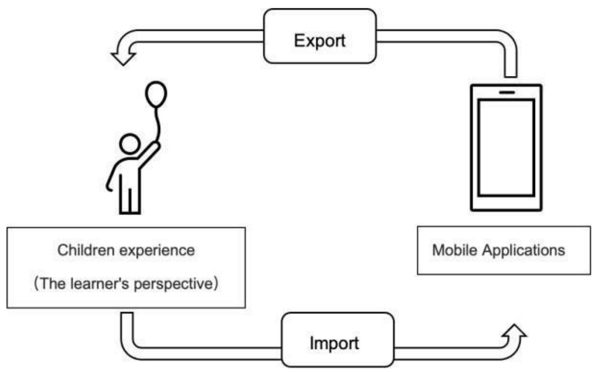


Figure 2. Children's video game interaction level architecture.

Secondary analysis structure: The usual output methods for mobile app-based products are mainly visual, auditory, tactile, and sensory. Children Children's information input is in the form of gestural touch swipes, sound, and gravity sensing. As shown in Figure 3.

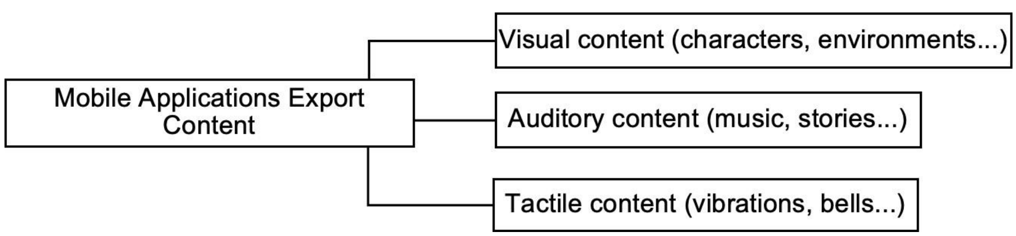


Figure 3. Elements of the system Export.

Three-level analysis architecture: Children's participation in class can be judged by behavior, sense, and emotion (Furrer & Skinner, 2003). Our research will also formulate an analysis table of interaction levels of preschool children's video game products according to these three aspects, as shown in Table 1. It will also extend into the details of the analysis scale.

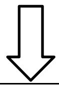
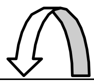
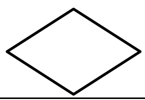
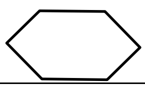
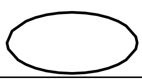
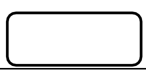
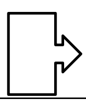
Table 1. *Interactive Hierarchical Analysis of Children's Video Game Product*

Behavioral interaction	The instruction of the system action appears, indicating the following behavior and action of the child.
	The presence of scene transformation gives children the right to make independent choices.
	Give children body movements space to play; in the process of play, children can fully mobilize their body movements.
	Meet the characteristics of children's memory; the basic rules and plot settings of the game can be remembered in a short time.
	Rules of behavior during the game are practical, not abstract concepts.
Sensory interaction	During the game, the time information appears. And to be able to experience the passage of time in the game.
	Special effects for the concept of space experience; in the game, children can experience the object of space forever.
	For visual media design, the layout of game scenes differs from the social and natural environment. After feeling the simulated real experience, it can be distinguished from the actual situation.
	Experience of hearing; real and natural sound; non-electronic special effects.
	The touch experience is colorful, not-finger fingers.
	The critical content can be highlighted in the design and has a specific attraction to children.
	The training of language, join the training for children listening, speaking, reading and guidance.
Emotional interaction	The function of interaction and communication and sharing with friends.
	There is emotional communication in the game; you can interact with significant concepts in the game, such as expressions.
	The game scene development is naturally not abrupt, and the plot is coherent.
	The scene setting of the game conforms to the law of the natural development of life.
	Identify the right and wrong skills in the game's tone and guide the natural plot.
	Moderate difficulty; satisfying child self-actualization.
	Design of parent-child interaction; satisfy children's emotional interaction with parents.
	Whether games can evoke children's past experiences and deepen and strengthen past experiences.

4.1 Analytic flow chart design

See the engineering design flow chart for expression. In this paper, the design of the flow chart as the main presentation form, the visual performance of children's video games in the process of interaction structure. The rectangle is used to represent the user's behavior. The rounded rectangle represents the user's thinking when using a video game product, and the diamond represents the behavior and judgment of the system. Arrows are mainly utilized as directional icons to indicate the direction of user actions and the flow direction of the game to analyze and intuitively show interactive design behaviors in children's video games. The specific representation is shown in Table 2.

Table 2. *Meanings of Icons in the Flow Chart*

Interactive category	**icon**	**Meaning in the flowchart**
User action		The user's finger's basic direction of movement.
User action		The basic action of the user's wrist operation.
User behavior		Indicates the user's movement habits and thinking movements.
System behavior and judgment		Indicates response of the system to the user behavior.
Game start		Indicates the start of the game.
Game over		Indicates the end of the game.
Users think about action		Indicates user's thinking and judgment of behavior while using the product.
The game cycle		It indicates the game loop.

4.2 Game Application case analysis

Select the most downloaded educational game as a filter. This study selected the Little Panda series from Apple Store, and more suitable for younger children. Therefore, this study will choose a game from this series as a case study. As shown in Table 3.

Table 3. *Game Information*

Game Name	Baby Panda World
Game Introduction	Android developer *BabyBus* has been working on the platform since 2011. The two most significant apps on *BabyBus* are Baby Panda World and Baby Panda's Supermarket. Both apps are highly rated and have been downloaded more than 100 million times on Google Play. It has a wide range of options. You can take pleasure in managing your business and engaging with delicious food, or even succeed as a renowned fashion designer.
Game Storyline	Food, animals, careers, painting, and music are the five topics to research. Over 100 different interactive game categories include games like princess dress-up, graffiti, desert adventure, and underwater rescue. The game features linguistic hints, and each mini game has a plot that it corresponds to. There are no games with competition.
Game Method of Operation	Baby Panda World allows children to explore, learn and immerse themselves in various activities or tasks related to situations they might encounter in the real World. All games are based on engaging animations of baby pandas and their friends. Players can complete tasks in a highly visual and interactive manner. A clear verbal explanation of the required tasks is given at the beginning of each competition. Emphasizes listening skills and following instructions. Motion manipulation uses swiping or tapping on the phone screen.
Game Example	A small *train* game can be found in this game, for example. Children can first click on the screen to choose a locomotive and body. He was a train driver back then. The train started to whistle and move after pressing a button, traveling from station to station as shown on the map. A distinct mission will be assigned to each station. Examine the tickets of other passengers and keep track of their final destination while the train is still moving.

According to table 2. The operation process of the case game *Train* is shown in Figure 4.

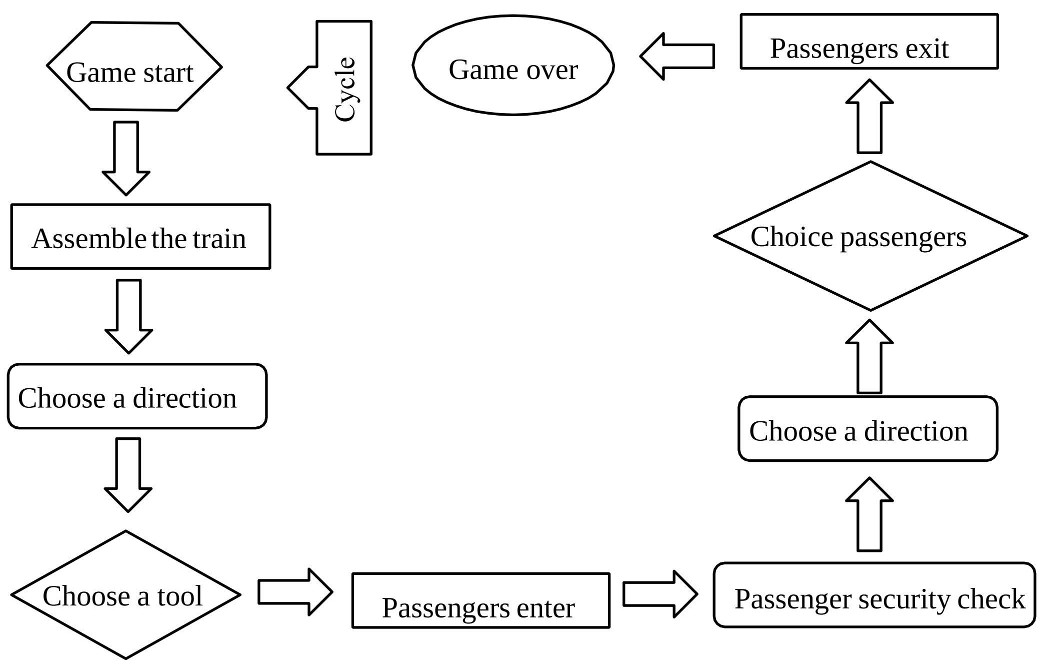


Figure 4. The flow of the game case

6. Conclusion

Computers have taken over visual, auditory, olfactory, tactile, and other signals in digital electronic products (Karray et al., 2008). However, most children's video games focus on reconstructing vision and hearing. For example, the incredible special effects of the *Baby Panda World* series bring visual and auditory impact experience to children. Marsh (2006) studies found that most three- to four-year- old children had established early digital literacy. Already the advent of the digital era is proving irresistible. Children must perceive the real natural world through personal touch (Beery & Jørgensen, 2018). For example, the tactile sensation of children touching the screen in a restaurant game is different from entering a real-life restaurant activity, and the taste of an authentic restaurant is not experienced. However, there is no denying that video games give children a whole new experience. Analysis of the problems with existing video game software for children reveals that most educational game applications overemphasize educational content and ignore children's cognitive development. It was found that most educational game applications designed for children overemphasize educational content and forget the cognitive developmental requirements of children. The actions are also limited, and the games are designed more to satisfy the market's needs than the children's developmental perspective.

User-centered gamification interaction strategy to improve the utilization of online education resources (Liu & Peng, 2013). Children interacting with intelligent characters, supporting healthy lifestyles, learning skills, mobile, tangible and ubiquitous computing, and designing and evaluating technologies are among the focus of research in interactive design games for children (Hourcade, 2007). In the design of children's video games, the most important thing is not the game's look, the interface, or the special effects. Children should be allowed to experiment with body motions, especially in motion interaction design. In the process of play, children can fully activate their body movements. The critical core is the design of the interaction structure (Barab et al., 2005). Although a game directly touches the user with its interface, appearance, and special effects, the core of a video game is the interactive structure of the game. Whether the design of the interactive system in the interactive design of electronic games has the characteristics of humanization, conforms to the development of children in many aspects, rejects the addiction to electronic games, and includes more extensive interaction with real life in the process of playing. The multi-mode game experience is the future development trend and research direction.

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The Effect of Online Collaborative Learning Environment with Integration of Technological Tools Towards Student's Achievement

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Abstract: Student performance after learning a topic is necessary to be achieved in school. Besides, teachers should have appropriate integrated teaching strategies to help students learn in class. Therefore, the purpose of this study is to investigate the effect of online collaborative learning that integrates technological tools for students' achievement in learning science. The impact of this study was measured by using an instrument called the Solar System Test to measure student achievement. This pre-experimental study was conducted on 30 Year 4 students from a school located in Johor Bahru, Malaysia. Descriptive analysis of the Solar System test showed that there was a significant difference between pre-test and post-test. The result proved that this research had positive impact on student achievement. In conclusion, this research helps teachers to develop an effective as well as a meaningful teaching and learning process, which is through the implementation of the 21st Century learning approach with the integration of technology tools in the teaching and learning environment.

Keywords: collaborative learning, achievement, technological tools, online learning

1. Introduction

Education in Malaysia promotes Higher Order Thinking Skills (HOTS) to diversify the learning environment. Higher Order Thinking Skills are the abilities of students to make use of knowledge, and skills in making reasons, solving a given task, and creating something new based on findings (Ministry of Education, 2013). The need for science environment learning will depend on many factors, such as the need of students and the characteristics of the science programme (National Research Council, 1996). For the past two decades, online learning and teaching can enhance students understanding of science and promote a good learning science environment. Nowadays, online learning can be an educational platform for teachers and students to learn (Allen et al., 2016).

To achieve this goal, the concept of online learning in science must be through proper design and effective utilisation of technology. The National Science Teachers Association (NSTA) defines online learning as an effective learning process created by combining digitally delivered content with learning support and services (Walter, 2001). Online learning should significantly enhance science teaching and learning and may be used to extend onside learning experiences.

Online learning is usually based on distant learning methods as online learning can be done while students and teachers are separated by distance. Online learning is when learning occurs by using a computer that is connected to the Internet (Vernadakis, 2011). Although online learning is not rigid to only distance-based online courses or learning, the global pandemic that we are facing today has forced education to coop with the current situation. Online learning can also be used in traditional classroom instruction that incorporates the planned and effective use of collaboration with interactive digital tools and resources. Online learning can give many benefits to promote better understanding amongst students (Hashmatullah & Tahir Hanad, 2020).

Collaborative learning is defined as a learning method used for learning a certain topic by a group of students (Nevine & Rasha, 2015). Collaborative learning is when an individual works in a group and everyone is responsible to assist and contribute information about the topic (Moore and Kearsley, 2012). Online collaborative learning is important as it can promote students to work together actively and teachers act as an instructor during the online learning process (Hamalainen & Vahasantanen, 2011).

Recent research on online collaborative learning examined how the features of traditional collaborative learning such as intentional design, co-labouring of individuals, and meaningful learning were approached differently in an online course than in a face-to-face course (Barkley et al., 2014; Major, 2015). Moreover, integrating multiple technologies through education is a must nowadays. Due to the recent global health problem, heading on 21st Century education, the use of technology in education nowadays is crucial as students are familiar with these technologies and they can learn better since technology can assist them in learning. Integration of computer technology can enhance the effectiveness of teaching and learning process. It is right to say that almost all subject ranges from mathematics, science, languages, arts, humanity, and other major fields can be learned more effectively through technology-based tools and equipment (Ghavifekr & Ibrahim, 2015).

2. Literature Review

The use of a collaborative approach in teaching and learning and the integration of technology tools such as Google Classroom in online learning are discussed in this section.

2.1 Online Learning

The pandemic forces those in the education field to change the way in delivering information. From the conventional classroom environment, teachers and students are switching physical teaching and learning to online learning environments (Wu, 2020). The teacher is required to teach creatively and innovatively to provide students with proper education (Markus, 2020). Online learning can be defined as student learning experiences, either occurring at the time (synchronous) or learning at their own pace (asynchronous) after being given a task to complete by using various devices, such as laptops and tablets with the Internet connection (Dhawan, 2020). Online learning is capable of bringing students and teachers to communicate with one another regardless of background, location, and time (Venter, 2018). Online learning provides information to be updated instantly without the need to gather students in one place (Steven,2018). A study by Shivangi (2020) claimed that online learning is a platform that creates a teaching and learning process was more students centred. Online learning can be accessed by students independently anywhere and they still can interact with teachers and peers for sharing information (Singh & Thurman,2019).

Online learning is distance learning by using technology devices with Internet access to gain learning experiences (Dhawan, 2020). This research suggests two online learning approaches which are asynchronous learning and synchronous learning. Synchronous online learning is an approach when students and teachers attend live discussions such as online video conferencing that provide the teacher as facilitator and students to act as active participants (Lisa,2021). The synchronous learning environment provides instant interactions between peers and teachers and probably forms some quick feedback during the transition of online learning (Littlefield, 2018). Active interaction occurs in the synchronous learning environment (McBrien et al.,2009). On the other hand, asynchronous online learning gives a chance for students to come up with ideas and strategies in conducting information and delivering the knowledge (Pratt & Palloff, 2012). Sander (2019) stated that asynchronous online learning gave students to arrange their schedules and did not tie them to specific courses.

Other online learning approaches include interactive online learning, individual online learning, and collaborative online learning (Sander, 2019). The interactive online learning approach provides non-linear delivering information as students and teachers can share their knowledge, and experiences in a two-way communication with various types of methods. The interactive learning approach trains students in problem-solving and developing literacy skills directly without students realised (Urh et al., 2015). Nowadays, collaborative online learning has become a new type of learning that students can achieve in a group even not being in the same building (Sander, 2019). Collaborative online learning is a group of students working together to arrange and create knowledge and understand through online platforms to solve given problems (Bates, 2015). Good generalisation and creative ideas will occur by presenting the idea based on a collaborative online learning approach (Amy, 2020).

Online learning occurs when teachers and students did not meet in the same building. According to Sun and Chen (2016), effective online learning must have online content for teaching and learning, active participation and interaction between students and teachers and the use of online technology tools. This feature is needed to promote ongoing discussion effective teaching and learning even if the teaching and learning environment occurs virtually. In addition, online learning may promote self- confidence and develop students' authenticities (Wong, 2020).

2.2 Collaborative Learning

Collaborative learning is defined as when teachers and students collaborate in the learning environment to form group activities (Liaw & Huang et al., 2009). A study by Waleed et al. (2015) stated that collaborative learning consists of both active interaction and students' relation with the subject learned. Others stated that collaborative learning is a method used by a few students working together in groups to achieve learning objectives (Nevine et al.,2015). Emaliana (2017) stated that collaborative learning is a student-centred approach in making the action in the learning process while teachers act as facilitators to guide them.

The value of cooperation provides equal outcomes for each student. Second principles provide learning opportunities without looking at their backgrounds, providing better achievement as raw ideas come from various levels of students. Positive independence refers to the contribution of ideas that comes up from each participant in the group to solve a task. Individual accountability principles are the responsibility of each group to contribute ideas amongst others. Both simultaneous and equal participation is important as collaborative learning require all participants to be involved actively and not passively. Working together will help students to develop their collaborative skills. Teamwork in groups will improve interaction amongst group participants, which is an important part of a successful collaborative learning (Yildiz, 2017).

In this research, the principle of collaborative learning by Peter Brunn (2014) was chosen as the guideline to integrate technological tools to see students' collaborative skills and their achievements. This principle states four principles in conducting online collaborative learning. The principles are building a good convenient learning environment before starting a teaching and learning session. The second principle is that teachers must guide students to come up with their ideas, and prior knowledge so that students learn and gain information on the right track. Conducting a creative delivery will promote student communication with peers in group activities. Lastly, the teacher must give space for students to express their feelings and form their groups.

Collaborative learning is a common approach in teaching and learning. Hamalainen and Katja (2011) stated that with collaborative learning approach, it helps teachers to strengthen their pedagogical bases and build good student-centred activities. In collaborative learning, teachers foster students to build up positive responses and interactions (Anouchka & Jeroen, 2019). Collaborative Learning gives a new shape to the learning environment. Collaborative learning makes the learning environment more comfortable as they can share their ideas freely without boundaries and are not worried about their ideas being rejected (Michael & Hameed, 2017). A learning environment with the integration of collaborative learning gives students more motivation for learning better as they have teachers and peers to help them to achieve the learning objectives (Affendy & Ismail, 2019).

In a virtual learning environment, Affendy, and Ismail (2019) stated that a collaborative learning environment will allow students to perform discussions and complete other types of group tasks virtually without seeing anyone face- to- face. Research by Waleed et al. (2015) stated that the use of collaborative learning in online media can provide engagement amongst students. Furthermore, the use of an online platform makes the group task accomplish more quickly and the result is of better quality than the individual work.

2.3 Technological Tools

Technology tools are described as equipment based on computers and the Internet that connect to deliver services such as information, communication and so on (Gupta, 2017). Technology tools also can be defined as electronic devices that can be used for gathering information, providing communication for the institution, organisations and many more (Ameen et al., 2019). Teaching and learning by using technology usually involve hardware devices such as laptops, computers, tablets, phones and so on (Ameen et al.,2019). Other than that, online platforms for creating teaching and learning environment are also necessary (Nina et al, 2017). Without a suitable online platform, the teaching and learning process will not occur.

Technology tools can use online recording so that teachers and students can give appropriate feedback based on given response (Yoshida, 2016). Furthermore, online recording can avoid students from losing important information, and they can refer to the recording multiple times without worry (Yoshida, 2016). Besides, the use of technology tools in teaching and learning can develop many 21st Century skills for students (Ain et al.,2018). The features from a variety of technology tools can be used to promote students-centred learning as they are more comfortable giving feedback with the help of technology (Clark et al.,2013). This feature is supported by the research by Raja and Nagasubramani (2018) stated that the use of technology tools in education can give a positive impact as teachers can make use of various tools to help students for better understanding.

According to Zhao et al. (2019), integration amongst technology tools can enhance communication between teachers and students. Active participation occurs when teachers and students used multiple technology tools as a medium to interact with each other. Research by Musca et al. (2016) stated that the integration of technology tools in online learning not only enhances communication amongst students but also amongst peers which can help them to achieve better performance in group activities. A combination of multimedia tools can help students to remember information transfer during teaching and learning (Farah et al.,2019). Ideas can emerge easily with the help of images, sounds, actions, and animation during learning. In addition, the combination of interactive mind mapping tools with other technology tools can increase student ideas, motivation, and achievement in certain topics (Chiou et al.,2013).

3. Methodology

In this study, a pre-experimental research design with one group pre-test and post-test (Campbell and Stanley 1963) was chosen. Thirty students from a Year 4 class were chosen as samples for this research. These students will take a pre-test, then receive treatment and finally takes a post-test to see the result.

3.1 Integration of Technological Tools in Collaborative Learning

While online teaching and learning were conducted, the researcher used a few technological tools such as video, and suitable computer software for creating learning lessons based on different phases. The details about the integration of technological tools in promoting collaborative learning during teaching and learning lessons can be seen in Table 1.

Table 1. *Teaching and learning process using collaborative approach*

Phase	Teaching and Learning Activity	Tools
Phase One (Create and support an inclusive, caring, safe learning community)	- Students were asked to watch a YouTube video posted in google classroom about the Solar System in general view	YouTube, Google Classroom
Phase Two (Integrate social and emotional learning into academic instruction)	**Gathering Information (Group activity)** - Students were divided into six groups and were asked to find out planets in Solar System and their characteristics.	Google Classroom, Google Meet, YouTube
	- Students used any online resources to find out information. - Teachers monitor and evaluate their collaboration in groups while building their google jam board.	
Phase Three (Lessons must build on and support students' intrinsic motivation)	- In groups, students will share their information to build a strong fact for each planet and transfer it to the google jam board. - Teacher monitor students' discussion on Google Meet	Google Meet, Google Jam Board,
Phase Four (Learning situations should focus on students' thinking and action)	**Sharing information** - Each group conduct a presentation using Google Meet and explain their findings about planets in Solar System. - Students answered some online questions using Google Forms based on the topic learned.	Google Meet, Google Jam Board, Google Form

3.2 Solar System Test

The questions were based on the topic of Solar Systems. This test consisted of 15 multiple-choice questions. The duration of the test was 40 minutes. Table 2 shows the distribution of questions according to the subtopic.

Table 2. *Question distribution according to subtopic of solar system*

Subtopic	Distribution Question	Total Question	Total Marks
Arrangement of planets	Question 3, 5,	2	2
Characteristic of planets	Question 2, 6, 7, 11, 12, 13, 14,15	8	8
Orbit and temperature of planets	Question 1, 4, 8, 9, 10,	5	5
	Total	15	15

The reliability of the test was also conducted in this study. Ten students were asked to answer the question by using the test-retest method. Question shuffling was applied during this procedure to avoid the risk of copying the answer. Other than that, shuffling the multiple answers was one of the steps in this reliability procedure. After the data was analysed, the coefficient alpha was at 0.852 which was near 1.0. Therefore, it can be concluded that the instrument was reliable and can be used in pre-test and post-test.

4. Data Analysis and Results

This study employed a quantitative research design. All the data collected were analysed based on descriptive analysis and inferential statistics by using SPSS software. Table 3 shows the scored data for every student in pre-test and post-solar system tests.

Table 3. *Statistic analysis of pre-test and post-test*

Student	Pre-Score	Post Score	Difference	Student	Pre-Score	Post Score	Difference
S1	12	15	+3	S16	13	15	+2
S2	12	13	+1	S17	12	14	+2
S3	8	9	+1	S18	14	14	0
S4	10	10	0	S19	4	7	+3
S5	11	12	+1	S20	11	13	+2
S6	10	14	+4	S21	11	12	+1
S7	10	14	+4	S22	7	11	+4
S8	12	13	+1	S23	5	9	+4
S9	11	12	+1	S24	15	14	-1
S10	10	15	+5	S25	9	14	+5
S11	10	12	+2	S 26	13	13	0
S12	10	12	+2	S 27	15	15	0
S13	13	13	0	S28	7	9	+2
S14	11	12	+1	S29	8	12	+4
S15	9	11	+2	S30	10	11	+1
	Mean Pre-Score		**10.43**		**Mean-Post Score**		**12.33**

S= Student n=30

Based on the result analysis of the pre-test in Table 3 above, the lowest mark was obtained by student 19 which was 4 marks out of 15. The highest mark was achieved by students 24 and students 27 with 15 marks out of 15. In the post-test, the lowest marks were obtained by student 19 with 7 marks out of 15. The highest marks for post-test were achieved by student 1, student 10, student 16 and student 27 with 15 marks out of 15.

The marks difference between pre-test and post-test can be seen in Table 3 above. The differences value was obtained by finding the differences between post-test and pre-test marks. The differences value was important to know if the respondent achievement increased or decreased after the intervention was made. Based on the table above, 24 respondents showed an increase in their achievement in the pre-test and post-test after the intervention. The highest achievement was achieved by student 10 and student 25 increasing by 5 marks. However, there was a respondent which was student 24 who decreased in achievement by 1 mark.

Overall, the achievement from pre-test and post-test could be clearly seen through comparison between the pre-test and post-test mean values. The mean value had increased by 1.9 between the pre- test and post-test. The analysis data showed that online collaboration by using Google classroom with the integration of technology tools improved the students' achievement. Normality tests were conducted for pre-test and post-test before further analysis to see if the data was normal or not normal. Based on the normality test obtained, the sig value for Shapiro Wilk was 0.034. The data was not normal as the sig value was also less than 0.05. Based on the normality test, the Wilcoxon Signed Rank test was chosen as a non-parametric test to analyse the data. The statistical result run by the Wilcoxon Signed Ranked Test is shown in the table below. Wilcoxon Signed Ranked Test was used for the pre-test and post-solar system test to determine if there was a significantly different between pre-test marks and post-test marks after the intervention was implemented. Two hypotheses were built to determine the result.

H_0: There is no significant difference between the mean of pre–Solar System test and the mean of the post-Solar System test after the intervention was implemented.
H_a: There is a significant difference between the mean of pre–Solar System test and the mean of the post-Solar System test after the intervention was implemented.

Based on *Wilcoxon Signed Ranked Test*, the sig (2-tailed) value was 0.00. This value was less than alpha value ($p < 0.05$). Hypotheses null (H_0) was rejected. There was a significant difference between the mean of the pre–Solar System test and the post-Solar System test when the intervention was implemented in the teaching and learning process. It can conclude that the intervention gives a positive effect on student achievement.

5. Discussions

The effect of an online collaborative learning environment with the integration of technology tools approach towards student achievement can be seen through comparison between pre-test and post-test. Overall, based on the test conducted, the mean value obtained by students in the post-test increased from 10.43 to 12.33, which increased by 1.9. The results showed that the application of online collaborative learning with the integration of technology tools approach in teaching and learning could enhance student achievement in Solar System topic.

Furthermore, the result showed that there was a significant difference in score mean from pre- test and post-test, which was a value of $p = 0.000 < 0.05$. Based on this result, it was proven that online collaborative learning with the integration of technology tools could enhance student achievement in their learning process. This showed that the use of various technology tools and a collaborative learning approach helped to increase student achievement.

The results from this study were parallel with previous research which proved the benefit of using technology tools in the teaching and learning process (Iqbal & Khan,2015). This is because technology tools had potential value to create effective and high-quality learning activities (Nofaizah & Salmiza, 2019). Technology tools in the teaching and learning processes can give meaningful learning experiences to the students, and thus create various learning environments (Izwan et al, 2018). Other than that, Didem (2017) stated a few advantages of using technology tools in the teaching and learning process which helped to improve students' understanding and enhance teaching-learning quality and helped to motivate students to learn more about a certain topic. Other research by Ahmed & Shimaa (2015) also found that the use of technology tools in teaching and learning, such as educational videos, and e-books gave a positive effect on the academic achievement.

Integration of technology tools in the teaching and learning process has the potential to support and enhance the quality of teaching and learning (Izwan et al., 2018). For example, research by Rajendra (2017) which studied the connection between the integration of technology tools towards student achievement found out that there was a correlation relationship between the integration of technology tools in teaching and learning and student achievement. Research by Wael (2016) that used YouTube videos in the teaching and learning lessons found that the use of YouTube application can create more effective and efficient learning environments. These findings were also supported by another research by Raja and Nagasubramani (2018) which said that the integration of technology tools can attract students' interest and develop creative thinking.

Furthermore, another factor contributing to the increase in student achievement in this research was influenced the online collaborative learning approach that was implemented in the learning process. Fransisco and Maria (2016) said that it is important to ensure the effectiveness of using appropriate technology tools with suitable learning pedagogy to use in teaching and learning activities. Teachers must know about learning approaches and skills in using technology tools as this knowledge will help teachers in creating effective online learning environments for students (Triayudi & Iskandar, 2019). Integration of technology tools in the teaching and learning process without proper planning will cause the learning objectives not to be achieved. This is also agreed by Jihan Rabah (2015) that teachers with knowledge of technology tools skills will have additional value as it helps to make use of the technology easier in the teaching and learning process.

Based on the importance of choosing a suitable learning approach, this research used an online collaborative learning approach that integrates with technology tools and research findings showed a positive impact on student achievement. The online collaborative approach used in this research was based on Online Collaborative Approach by Peter Brunn (2014) consisted of four phases which were creating and supporting an inclusive, caring, safe learning community, integrating social and emotional learning into academic instruction, and lessons must build on and support students' intrinsic motivation and learning situations should focus on students' thinking and action. Few studies supported the findings of this research about the effectiveness of the online collaborative learning approach in teaching and learning. Based on a study by Alex and Yuan (2017) which also researched the online collaborative approach showed that students gained high scores on their tests than the control group. Other than that, a study by Ronny and Timothy (2019) claimed that teachers view that implementing an online collaborative learning approach in secondary school give a positive impact on science subjects. The implementation of an online collaborative learning approach in the learning process can motivate students to participate actively in online activities which can help in improving their achievement.

In conclusion, the teaching and learning process using online collaborative learning approach integration with technology tools was proven one effective way to increase student achievement in education. This research finding is parallel with other previous studies as discussed above. An online collaborative approach and integration with technology tools can create a conducive, active, and interactive online learning environment. The use of technology tools with the appropriate learning approach, interesting and effective teaching and learning processes can be achieved to support education in Malaysia.

6. Conclusion

In conclusion, based on the research findings, it was found that almost all students showed positive results in their achievement. Therefore, it is hoped that this type of learning approach can be implemented in the education field to promote active learning. The young generation nowadays specifically the Alpha generation are exposed to various technology tools in their daily life. Therefore, it is believed that the integration of technology tools in an online collaborative learning approach was proven effective in enhancing student achievement, especially in science subjects if a suitable learning approach is applied.

Other than that, this research can give exposure to the teachers about the benefits of using technology tools in online learning. The use of technology tools can help teachers build and expand their idea and creativity to create an interesting learning environment (Kinshuk et al., 2016). Teachers must have technology tools skill as this is important to strengthen the use of technology in the education field. When teachers mastered some elements of technology tools in their classroom, it will attract students' attention as information is delivered variously, and thus increasing students' understanding of a certain topic (Ming Hung et al., 2017). Technology tools in teaching and learning also help teachers to monitor, control the class and train students with good value and develop students' presentation skills (Asri & Santiana, 2017).

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A Review: The Effectiveness of Using TikTok in Teaching and Learning

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Abstract: Social media platforms such as YouTube, Facebook, Telegram, and so on have influenced pedagogical practices in improving student learning. However, there is limited literature on the use of the TikTok application in teaching and learning and whether this platform helps students or is only for entertainment. The TikTok application is one of the social media platforms for sharing short videos that are rapidly increasing in popularity. Therefore, this study reviewed recent literature on the effectiveness of using TikTok in teaching and learning from primary to higher education learning. Seven research articles were identified as relevant to this review through the predetermined criteria. The purpose, method, subjects and outcome of the studies were reviewed. It indicated that a complex subject like chemistry could attract the public to enjoy learning chemistry at home and improve undergraduate students learning. Other than that, learning skills like dance and sports through TikTok also positively impacts students. Language subjects like English as a Second Language utilise TikTok to enhance students' listening, writing and comprehension skills. Future educators in primary, secondary, and higher education may think about integrating TikTok into their teaching and learning strategies to stimulate the creation of original videos that adhere to instructional design principles.

Keywords: TikTok, Education, Effectiveness, Review

1. Introduction

Global Digital Report 2021 highlights that the total number of social media users worldwide has been raised to 4.20 billion, and it continues to show an increasing trend. Today, the use of social media has penetrated many segments of society, including education. The use of social media in education is believed to increase students' knowledge as it facilitates a knowledge-sharing environment (M ̈a ntym aki & Riemer, 2016). The ability of social media that enables the students to communicate with peers and experts in the network and its potential to reach a mass audience mainly influences the students to use social media in their learning activities. Students mostly use social media to search for information and collaborate with others (Rasheed et al., 2020). Therefore, using social media is expected to increase knowledge sharing among students, which can lead to improved learning performance.

Social media can be classified into four categories known as experience- and resource-sharing tools, media-sharing tools, social networking tools and communication tools (Zgheib & Dabbagh, 2020). Social media examples include Facebook, Twitter, YouTube and TikTok (Zgheib & Dabbagh, 2020; Salehudin, Arifin, & Napitupulu, 2021; Dean, 2022). Every social media platform has a unique set of advantages that help to support the learning process. For example, Facebook and Twitter support both formal and informal learning by exposing students to learning methods through virtual communities. This helps learners improve their communication skills, motivation and ability to work together. Further, YouTube is a media-sharing tool that allows learners to create and share videos, upload and tag photos, leave comments on photos and videos, summarise lecture notes, and record demonstrations. (Zgheib & Dabbagh, 2020).

Foremost, TikTok is one of the social media applications that became a global success, where it recorded more than 3 billion downloads worldwide as of 2022 (Dean, 2022). "The Tik Tok application is an application to create and share various short videos in vertical format, which is played by simply scrolling the screen up or down" (Herlisya & Wiratno, 2022). Zaitun (2021) surmised that TikTok delivers a promising platform to be used as an interactive learning medium that can enhance students learning performance, especially their speaking and writing ability. The internal feature of TikTok is enabled this application is to be used as a learning tool in many courses. This study reviews the effectiveness of using TikTok as a pedagogical tool from primary to higher learning institution levels.

The use of TikTok is one of the important areas of research in the educational context. Many empirical studies were conducted to identify the effectiveness of using TikTok in the educational context (Adnan, N. I., Ramli, S & Ismail, I. N, 2021; Niyomsuk & Polyiem, 2022; Paloma Escamilla- Fajardo, Alguacil & López-Carril, 2021). However, there are limited review studies on the effectiveness of using TikTok in the educational environment. Thus, there is a dire need to review the effectiveness of using TikTok as a pedagogical tool in the educational context. This review is believed to contribute to expanding the understanding of stakeholders in educational institutes about the effectiveness of using TikTok in teaching and learning activities.

2. Methodology

This review aims to examine the current research literature regarding the effectiveness of using TikTok as a pedagogical tool for the years 2017 to 2022 in the context of primary to tertiary education. The authors conducted the search through Google Scholar, Elsevier, Scopus, IEEE and Proquest databases. In particular, this review intends to address the following broadly focused research question: "What is the effectiveness of using TikTok as a pedagogical tool at the primary to tertiary education level?"

2.1 The search procedure

The articles included in this review were selected through a comprehensive search of publicly available literature, mostly through manual electronic searches of the Google Scholar, Elsevier, Scopus, IEEE and ProQuest databases. The keywords "TikTok video, educational tools, social media application, short video, ICT tools, learning, teaching, digital learning, mobile learning, education" were used to identify the articles.

Articles for the review were selected based on the following criteria (a) the article was published between 2017 and 2022, (b) the article was published in English, and (c) the article related to the use of TikTok as a pedagogical tool in primary to tertiary education level. Based on the criteria, 7 studies from 6 prominent peer-reviewed research journals and one indexed conference proceeding were identified as eligible for the review and were comprehensively analysed by the authors. Table 1 shows the summary of the findings.

2.2 Data analysis

At first, the authors read the abstract of each article to guarantee the article met the predetermined criteria. Then, the entire article was read to extract the content that was relevant to the research question of this review. The findings were tabulated based on the purpose, methodology, courses and outcome of the study (Table 1).

3. The Effectiveness of Using Tik Tok in Teaching and Learning Activities

Past studies have reported that TikTok has excellent potential to be used as a pedagogical tool. TikTok is believed to increase students' cognitive and affective learning performance. For instance, Escamilla-Fajardo, Alguacil and López-Carril (2021) reported that using TikTok among sports science students promoted student motivation, created an engaging learning environment, and encouraged the development of skills such as creativity and curiosity. The researchers argued that TikTok is a suitable medium for teaching expressive courses with creative content such as movement and music.

Similarly, Niyomsuk and Polyiem (2022) admitted that integrating TikTok in teaching Thai traditional dancing art improved the Grade 7 students learning performance. TikTok has created satisfying learning experiences among students. This study delivers empirical evidence that TikTok could deliver promising results to courses involving practical skill development.

TikTok is also found to be a useful tool to learn a language. For instance, Adnan, Ramli and Ismail (2021) highlighted that TikTok could be used as a comprehensive tool for improving English second language (ESL) students' listening skills. According to the authors, learning English via TikTok, which delivers interactive listening, is believed to engage students in tasks that demand them to negotiate meaning and immerse them in realistic and meaningful dialogue. TikTok presents words and visuals at the same time. It enhances students' understanding and enables them to understand new English words easily. The authors also investigated the students' perspectives on the benefits and defects of incorporating TikTok into classroom learning. It was found that the students preferred the new Tik Tok video method compared to learning from the traditional mind-map due to the variety and interesting features of the Tik Tok app. The authors also claimed that the utilization of TikTok relates to five of the principles in multimedia learning based on Mayer's (2002). This showed the effectiveness of Tik Tok as a learning tool that provides students with a better learning experience.

Meanwhile, Yunus, Zakaria and Suliman (2019) highlighted that using social media such as TikTok in the ESL classroom breaks the barriers in learning English writing skills and converts it into a constructive learning atmosphere. The authors reported that the use of social media assisted the rural primary students to improve their English writing skills as most of them felt that writing skill is the most challenging part of learning. Integration of TikTok enabled the students to learn better and improve their writing process and performance. This is because TikTok assisted the students to learn new things and gain the appropriate knowledge to scrutinize their writing skills.

Other than language learning, a study by Hayes, C., Stott, K., Lamb, K. J., & Hurst, G. A. (2020) was conducted by utilizing TikTok videos in chemistry learning by undergraduate students. Interestingly, using TikTok not only helps undergraduate students learn chemistry but also enhances public engagement in chemistry and science education. The undergraduate students develop 16 educational videos and uploaded all of the videos in one account, namely, "The Chemistry Collective", and have gained approximately 8,500 views. It was found out that the viewers of these Tik Tok videos strongly agreed that they had learned something new about chemistry since watching these videos and had an increased interest in chemistry. This indicates that learning chemistry via Tik Tok also can engage the public that learning chemistry can be enjoyable and be performed at home in daily life.

A study by Radin, A. G., & Light, C. J. (2022) used the TikTok platform as an adaptation to the challenge of teaching during the pandemic time. TikTok was used as a teaching method in the second semester of a three-semester CURE sequence at Binghamton University. Students were challenged to create TikToks about the research being done in the lab or their team's proposed research projects. Students indicated that teaching via TikTok helped learn new content remotely before entering the lab. They especially valued #labfails (laboratory mistakes or challenges) shared by undergraduate peer mentors, both to learn from and to feel less isolated during the difficulties of research setbacks.
This shows that TikTok can be helpful in teaching about research in the lab to undergraduate students.

Another study by Rimasari Pramesti Putri (2021) used TikTok during the pandemic for her dance course class. She aimed to provide online learning innovations in her course. It was found that the TikTok application can be used as a learning medium to enhance the students' creativity and also develop their digitalization skills during a pandemic. It also found that students are able to use technology in learning dance, express their creative dance ideas in digital form and increase the power of exploration and improvisation in creativity. She also said that by publishing videos on the TikTok application, the students can show their dance originality and can be followed by the public.

Table 1. *Purpose, Methodology and the Outcomes of the study*

Authors	Purpose	Methodology	Course; Sample	Outcomes of the study
Paloma Escamilla-Fajardo, Alguacil & López-Carril (2021)	Explore the educational experience and pedagogical effect of using TikTok in the sports science course	Mixed method	Sports Science; undergraduate	TikTok promoted student motivation, created an engaging learning environment, and encouraged the development of skills such as creativity and curiosity.
Niyomsuk & Polyiem (2022)	Investigate the effectiveness of TikTok as a learning tool and investigate students' satisfaction	Quantitative	Thai Traditional Dance; primary students	TikTok increased students learning performance and satisfaction
Adnan, N. I., Ramli, S & Ismail, I. N. (2021).	Investigate the usefulness of Tik Tok as an educational tool in English course	Quantitative	ESL; undergraduate	TikTok could be used as a comprehensive tool for improving the listening skills of English second language (ESL) courses students
Yunus, Zakaria & Suliman (2019)	Investigate the potential use of social media (TikTok) in improving writing skills among primary students.	Quantitative	ESL; primary students	TikTok assisted the students to improve their English writing skills
Hayes, C., Stott, K., Lamb, K. J., & Hurst, G. A. (2020)	Utilizing TikTok and Systems Thinking to Facilitate Scientific Public Engagement and Contextualization of Chemistry at Home	Quantitative	Chemistry; undergraduate, public	The viewers of these TikTok videos strongly agreed that they had learned something new about chemistry since watching these videos and had an increased interest in chemistry.

Radin, A. G., & Light, C. J. (2022).	Investigate the use of TikTok to teach science communication skills	Qualitative	Science communication; undergraduate	Students indicated that teaching TikToks helped learn new content remotely before entering the lab.
Putri, R. P. (2021)	Utilize TikTok during pandemic for dance course	Qualitative	Dance; undergraduate	The results of this study indicate that students can apply technology in learning dance, express their creative dance ideas in digital form and increase the power of exploration and improvisation in creativity

4. Conclusion, Discussion and Suggestions

From the seven papers reviewed above, most of the studies applied quantitative research and utilized questionnaires to collect data. Only one preferred to use a mixed-method study. The other two studies used qualitative methods through their research. The analysis of the subjects that applied TikTok in their teaching and learning are Sports Science course, English course including listening and writing skills, Science course like chemistry and the ethics in the Science Lab and also a dance course. From this study, we can conclude that various courses utilise TikTok to enhance their learning and received positive feedback on their use of TikTok in education.

Furthermore, looking at the excellent total views (8, 500 views) of complex topics like chemistry that may be found boring for students showed that their videos could engage students and the public that learning chemistry is enjoyable and they can do it using materials that can be found at home. This showed that students could produce creative and fun educational videos that can engage students and the public to learn chemistry. We also can conclude that TikTok can be a source of knowledge to learn science in a short time.

One of the best features of TikTok is the videos are short, easy to create and convenient to share. This may produce students or teachers that are creative in delivering their learning and share to the public. In the future, educators in primary and secondary schools and higher education may consider incorporating TikTok into teaching and learning practices that may encourage producing a creative video that follows the instructional design principles.

In this study, we only reviewed the aims, methods of research and the outcome of the study. For future research, the teaching strategies implemented when using TikTok in teaching and learning also can be analysed.

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The Role of Epistemic Curiosity in A 3D Virtual Game for Science Learning

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Abstract: In this study, we developed a three-dimensional virtual game to help students understand the concepts of evaporation and condensation. Next, we developed a research model to examine the relationships between epistemic curiosity, situational interest, learning engagement, and science achievement. Finally, we investigated the mediating role of situational interest in the proposed model. To this end, we will collect data from approximately 75 6thgrade students in Taiwan. We will analyze the results of the measurement model, as well as the underlying structural relationships, through PLS-SEM.

Keywords: epistemic curiosity, situational interest, engagement, science achievement

1. Introduction

Game-based learning (GBL) is defined as learning by accomplishing tasks or solving problems through games. Students may create strategies for solving problems or understanding complex systems while playing (Prensky, 2001). Several studies have demonstrated the positive effects of implementing GBL in science education, such as improvements in students' learning motivation (Chen, 2019), engagement (Eltahir et al., 2021), and performance (Lei et al., 2022).

With recent advances in technology, games can be played in new forms, such as virtual environments. Virtual environments provide three significant features: a three-dimensional (3D) space, a first-person view, and an interactive environment (Franceschi et al., 2009). 3D virtual environments can also be regarded as desktop virtual reality (VR) (Makransky & Petersen, 2021). 3D virtual gaming has been confirmed to improve students' learning motivation (Makransky & Petersen, 2019) and content knowledge (Liu, Li, & Ji, 2022). Thus far, few studies have highlighted the underlying relationships between affective factors and students' learning outcomes, such as engagement and achievements, in the context of emerging technologies (Lee et al., 2022).

In this study, we have developed a 3D virtual game to help students understand the concepts of evaporation and condensation at the elementary school level. Although evaporation and condensation are essential concepts in science education, elementary students tend to have alternative conceptions and consequently may find it difficult to differentiate between the two concepts (Tytler, 2000). We also developed a hypothesized model examining whether epistemic curiosity and situational interest can predict students' learning engagement and science achievement within a virtual reality game environment (Cheng, Lee, Hsu, 2022).

1.1 Epistemic Curiosity (EC)

Berlyne (1954) first proposed and conceptualized epistemic curiosity (EC), indicating that simulating curiosity and experimental spirit may promote intellectual development and academic achievement. Scholars further described EC as the desire to acquire intellectual information due to the knowledge gap (Loewenstein, 1994) and the demand of exploring an academic environment (Grossnickle, 2016). EC may prompt people to learn new things to reduce their knowledge gaps (Litman, Hutchins, & Russon, 2012).

Litman (2008) suggested that EC includes two types of personality traits: interest-type (I-type) and deprivation-type (D-type). I-type EC occurs when people learn new information to satisfy their inner joy, and students with I-type EC tend to take pleasure in seeking new information (Litman, 2010). The intention to minimize information deprivation may cause people to develop D-type EC, which is related to negative emotions concerning the lack of required information, and relief after the information is obtained (Grossnickle, 2016). Students with D-type EC may experience uncomfortable "need to know" feelings, and a desire to reduce the feeling of uncertainty (Litman & Jimerson, 2004; Litman & Spielberger, 2003). I-type EC is considered to be related to interest and the joy of discovering new information, whereas D-type EC correlates to negative emotions such as anxiety and anger (Litman & Spielberger, 2003).

Studies have considered EC a variable of personal traits and conducted research in the fields of online (Fang et al, 2019) and game-based (Hwang et al., 2019) learning. Consequently, EC was found to be related to learning behavior such as online help-seeking (Cheng, 2019). Hong et al. (2019) found EC to positively affect learning performance; the same results were subsequently confirmed by Hong et al. (2020). Huck et al. (2020) found that I-type EC significantly affects students' cognitive engagement and motivation during GBL.

There is still a lack of research associating students' EC with other affective factors or learning outcomes (Lee et al., 2022). Arnone et al. (2011) also suggested investigating relationships between curiosity, interest, and engagement in technology-based learning. Accordingly, they developed theoretical models to explain how people learn.

1.2 Situational interest (SI)

Interest is considered a psychological phenomenon that arises from an individual's intentional involvement in a particular object, activity, or event (Pintrich & Schunk, 2002). According to Schiefele et al. (1992), interest can be categorized as personal interest (PI) or situational interest (SI). PI refers to a preference for an activity based on prior experiences, whereas SI refers to the affective perception acquired from interacting with the activity or environment (Schiefele et al., 1992).

Studies have shown that students' SI may be improved by technology-assisted environments, such as multi-user VR (Chen et al., 2016) or gamification design (Bressler et al., 2021), and augmented reality (Chen & Liu, 2020). Notably, most studies examined interest stemming from technology through one construct of SI. Nevertheless, researchers have suggested that it may be useful to examine multi-dimensional constructs (Deci, 1992).

Chen, Darst, and Pangrazi (1999) indicated that SI encompasses several concepts: novelty, challenge, attention demand, instant enjoyment, and exploration intention. Novelty refers to students' responses upon perceiving the gap between known and unknown information. Challenge refers to students' perception of a task's difficulty when compared against their abilities. Attention demand refers to students' attention and mentality during the activity. Instant enjoyment refers to the satisfaction that students gained from the activity, which compelled them to continuously participate.
Exploration intention refers to students' intentions to explore.

Studies have shown that enhancing novelty and exploration intention may improve the experience of instant enjoyment, and further activate SI (Chen et al., 1999). Virtual technology has been confirmed to foster students' SI, especially the novelty and challenge perceived while library touring (Lin et al., 2021).

1.3 Engagement

Engagement is defined as the observable and unobservable identity of the interactions between students and learning activities (Deci & Ryan, 2000). Since engagement represents students' needs and willingness to participate in the learning process, it directly correlates to higher levels of learning (Bomia et al., 1997). As learning engagement gradually received more attention over the past 20 years (Trowler, 2010), scholars and practitioners have come to recognize it as an important theoretical and practical cornerstone for school completion (Perdue, Manzeske, & Estell, 2009). Prior studies also indicate that academic emotion is an important variable, which may mediate the relationship between learning motivation and engagement. Accordingly, researchers have suggested further focusing on academic emotion in the future (Pekrun, Elliot & Maier, 2009).

Engagement is generally considered in terms of three dimensions: cognitive, emotional, and behavioral (Fredricks, Blumenfeld, & Paris, 2004). Cognitive engagement is defined as the effort tounderstand learning content, including self-regulation and meta-cognition. Emotional engagement is defined as the emotional response toward people, activities, and learning content. Students may experience varying emotions, such as happiness, frustration, and boredom. Behavioral engagement is defined as the observable behavior corresponding to academic achievements, such as course participation (Fredricks et al., 2004). Although both cognitive and behavioral engagements encompass actions taken by students, cognitive engagement refers to mental effort, which is less likely to be measurable by direct observation (Henrie, Halverson, & Graham, 2015).

Although student disengagement is a common problem in education (Drigas et al., 2014), simulation games have been confirmed to increase student engagement (Hamari, Koivisto, & Sarsa, 2014). Studies have also found a positive correlation between student engagement and learning achievement (Kinzie, 2010). Liu et al. (2020) investigated differences in learning engagement between VR and conventional classroom environments. The results showed that students using VR exhibited significantly higher learning achievement and engagement than students in a conventional classroom.

1.4 Hypothesized model and research purpose

In this study, we hypothesized that students' EC can directly and indirectly predict their engagement and learning achievement through SI (Figure 1). Recent studies have verified the associations between learning traits and engagement. Cheng (2020) found that EC (particularly I-type) may positively and significantly influence SI, especially novelty and exploration intention. Vracheva, Moussetis, & AbuRahma (2020) found that EC is positively correlated to and may accurately predict learning engagement. Cheng (2021) found novelty, instant enjoyment, and exploration intention to positively affect students' learning behavior. Studies have also shown SI to positively increase learning engagement in remote education (Sun & Rueda, 2012), and through a refutational test (Thomas & Kirby, 2020). Furthermore, SI has been suggested to be a mediator in the relationship between individual difference variables and academic performance (Bråten et al., 2014). Makransky and Pertersen (2021) also suggested exploring how SI factors mediate the relationships between virtual learning experiences and learning outcomes. Cheng et al. (2022) confirmed that EC may accurately predict SI and attitudinal learning, and the results of their study also demonstrated the importance of novelty, instant enjoyment, and exploration intention in this context.

Based on the aforementioned studies, three goals were formulated for this study:

(1) To develop a 3D virtual game to help students understand the concepts of evaporation and condensation.
(2) To explore relationships between EC, SI, engagement, and science achievement in DGBL.
(3) To explore the mediating effect of SI in the proposed model.

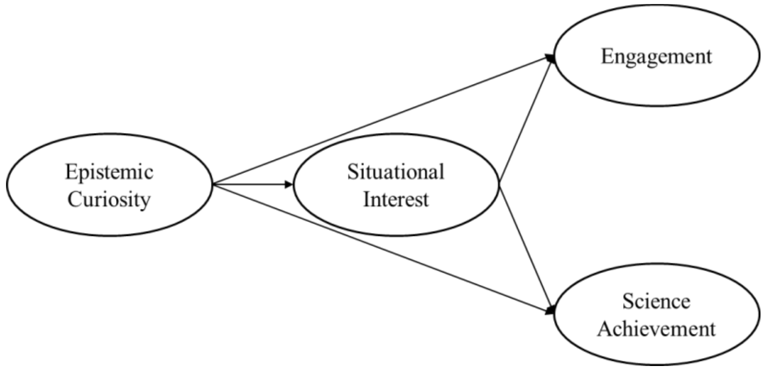

Figure 1. Hypothesized model showing relationships between epistemic curiosity, situational interest, engagement, and science achievement.

2. Method

2.1 Learning materials

We developed a 3D virtual game, Water in the House, designed for elementary school students (5th-6th grades) to learn the concepts of evaporation and condensation and locate objects associated with these phenomena in a virtual house. All objects in the house are based on real-life situations, enabling students to learn the underlying concepts through attempting and reflecting upon appropriate tasks (Kolb, 2014). In accordance with Sandberg, Maris, & Hoogendoorn (2014), we implemented GBL elements such as goals, challenges, and a leaderboard in our game. The game is displayed on a computer and allows players to freely explore the four rooms of the house by operating the keyboard and mouse.

2.2 Participants and procedure

We will collect data from approximately 75 6th-grade students in Taiwan. Students will complete a pre-test to assess their understanding of evaporation and condensation, as well as their EC scale, before playing the game for a maximum of 25 min. Subsequently, students will complete a post-test and post-survey to measure their SI and learning engagement.

2.3 Instruments

Three questionnaires were designed to test students' EC, SI, and engagement. Pre-test and post-test items were developed to measure the students' understanding of evaporation and condensation.

2.3.1 Questionnaires

The EC scale, adopted from Litman (2008), encompasses I-type (five items) and D-type EC (five items). I-type EC, defined as the satisfaction of discovering new information, includes items such as "I enjoy exploring new ideas." D-type EC, defined as the desire to eliminate uncertainty, is characterized by items such as "I spend hours on a problem because I cannot rest without an answer." Participants responded on a Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Past research has reported good reliabilities (I-type: $\alpha = 0.82$; D-type: $\alpha = 0.76$), with a moderate positive correlation ($r = 0.47$) between the two factors (Litman, 2008).

The SI questionnaire, adopted from Chen et al. (1999), consists of five scales: *novelty*, *challenge*, *attention demand*, *instant enjoyment*, and *exploration intention*. Participants responded on a Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Sample items of the scales include "This learning activity is new to me." (*novelty*); "It is hard for me to do this learning activity." (*challenge*); "I was focused while doing this learning activity." (*attention demand*); "This learning activity is exciting." (*instant enjoyment*); "I like to find out more about how to do this learning activity." (*exploration intention*).

The engagement questionnaire, adopted from Wang et al. (2016), comprises three scales: *cognitive engagement*, *emotional engagement*, and *behavioral engagement*. Participants responded on a Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Sample items of the scales include: "I think about different ways to solve a problem." (*cognitive*); "I feel good when I am doing this learning activity." (*emotional*); "I keep trying even if the learning activity is hard." (*behavioral*).

2.3.2 Science Achievement test

We designed multiple-choice assessments to evaluate students' understanding of evaporation and condensation. The pre-test and post-test are identical and include 15 items.

2.4 Data analysis

Data will be analyzed through partial least squares structural equation modeling (PLS-SEM). PLS-SEM is considered the second generation of multivariate analysis for verifying a relationship between variables (Fornell & Larcker, 1981). Analyses will be conducted with SmartPLS version 3.3. PLS-SEM is suitable for analyzing small datasets with sample sizes and does not require normal data distribution (Hair et al., 2021). The procedure of PLS-SEM entails assessing the reliability and validity of the measurement model's constructs and then assessing the path coefficients of direct and indirect effects between constructs of the structural model.

3. Expected results

This study proposes a research model to investigate structural relationships between EC, SI, learning engagement, and achievement in students. First, the results may establish the importance of I-type EC, as most studies have indicated a stronger influence of I-type EC compared to that of D-type EC (Cheng, 2020; Huck et al., 2020). Our results may also determine the importance of *novelty*, *instant enjoyment*, and especially *exploration intention*, in GBL environments, as prior research has indicated the benefits of learning in virtual environments for SI (Chen et al., 2016; Lin et al., 2021). Finally, we intend to compare our results with those obtained by Cheng et al. (2022), who proposed a similar research model that found EC to positively correlate with SI, attitudinal learning, and the mediation of SI.

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A Case Study of Secondary Students' Perceptions of STEM Education

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Abstract: This paper presents a preliminary analysis of a case study which investigated students' perceptions of STEM education in terms of (i) STEM interests, (ii) STEM values, and (iii) STEM-related career interests. The participants were 122 Grade-2 students (i.e., K8) from a secondary school in Hong Kong. Through a questionnaire-based survey, quantitative data were gathered from the participants before they were engaged in a STEM education program. Results showed that, before the program, there were connections between the participants' STEM interests, STEM values and STEM-related career interests. Furthermore, boys demonstrated higher STEM-related career interests than girls.

Keywords: STEM education, secondary education, students' perceptions, STEM interests, STEM values, STEM-related career interests

1. Introduction

Since the 21st century, the world has recognized the importance of STEM (Science, Technology, Engineering, and Mathematics) education. As a comprehensive discipline (Shanahan et al., 2016), STEM education implies interdisciplinarity (Sengupta et al., 2019), but few of these studies are considered interdisciplinary because they explicitly emphasize two or more disciplines (Takeuchi et al., 2020). With a combination of different disciplines, STEM could be more capable than a single discipline in solving complex real-world problems (Jong et al., 2022; Lau & Jong, 2022; Takeuchi et al., 2020). STEM education is fundamental for science or engineering professionals, people who do not receive STEM education can hardly pursue STEM careers (Xie, 2003; Killewald, 2012). In fact, the number of students who want to pursue STEM careers has been insufficient (Maiorca et al., 2021). Studies have investigated how to potentially increase students' career interests in STEM (Huang, Jong, King et al., 2022). Students' perceptions, especially career interests, are closely associated with their future career development. In this preliminary work, we examined the correlations between STEM interests, STEM values and STEM-related career interests, as well as the gender differences in students' STEM-related career interests.

2. Literature Review

STEM interest is one of the best predictors regarding students' future career choices. Students with higher interests in STEM are more likely to pursue a STEM-related career path (Nugent et al., 2015; Riskowski et al., 2009; Sanders, 2009). Previous research reported that students begin to think about their future careers at the secondary school level, and their career aspirations at this stage may forecast their future professions (Tai et al., 2006). Nevertheless, considerable data revealed that secondary students display a lack of interest in learning STEM (Subotnik et al., 2010).

Some studies have provided examples of how engineering design, i.e., connecting science, mathematics, and technology with real-world design tasks, can be used to increase students' interest in STEM (Shahali et al., 2016; Weng et al., 2022). The results showed that the real-world design tasks increased students' interest in STEM careers and enhanced their interests in cross-disciplinary education (Hiğde & Aktamış, 2022; Huang, Jong, & Chai, 2022). Thus, more institutions are exploring effective approaches for enhancing STEM interests and career interests based on cross-disciplinary real-world design tasks (Hernández-Serrano & Muñoz-Rodríguez., 2020).

In addition, other elements, such as STEM values and gender, have been reported to have direct or indirect connections to future STEM and college outcomes, and high mathematical proficiency moderates these outcomes (Fong & Kremer, 2020; Siregar & Rosli, 2021). Therefore, it would also be interesting to examine students' STEM values and their correlations to STEM interests and STEMrelated career interests.

Building on the experiences shared by researchers, we conducted a survey before the STEM project implementation to investigate secondary students' perceptions of STEM education including STEM interests, STEM values, and STEM-related career interests. In the meantime, the study also examined whether there was an association between gender, STEM interests, STEM values, and STEM-related career interests.

3. Methodology

3.1 Participants and Procedure

The participants of this study were Secondary-2 students (i.e., K8) in Hong Kong. Furthermore, at the time of investigation, they had not participated in our STEM programs. Thus, we could gather their prior perceptions of STEM before their participation in our program. After discarding incomplete responses, we retained 122 valid responses (n =122) in the analysis. Among the participants, 59.8% were boys and 40.2% were girls.

3.2 Measurements

The questionnaire consisted of three dimensions: STEM interests, STEM values, and STEM-related career interests. All items were measured on a 6-point Likert scale ranging from strongly disagree to strongly agree. The Cronbach's Alpha coefficient of each dimension is 0.88 for STEM interests (Luo et al., 2019), 0.91 for STEM values (Shin et al., 2019), and 0.94 for STEM-related career interests (Vennix et al., 2018). All alpha coefficients were above the cut-off point of 0.8, indicating the high reliability of each construct.

4. Results

4.1 Descriptive Statistics and Correlation Analysis

The means and standard deviations were computed. As shown in Table 1, students' perceptions of STEM were overall positive, with the means of all the examined dimensions above 3. Students' perceived STEM values (M = 3.89) and STEM interests (M = 3.78) were more positive than their perceived STEM-related career interests (M = 3.49). In addition, correlation analysis indicated that STEM interests, STEM values, and STEM-related career interests were strongly correlated with each other, with correlations ranging from 0.74 to 0.82 ($p < 0.001$).

Table 1. *Descriptive Statistics and Correlation Coefficient Matrix*

	Mean	SD	STEM interests	STEM values	STEM-related career interests
STEM interests	3.78	1.15	1	0.82***	0.74***

STEM values	3.88	1.12		1	0.78***
STEM-related career interests	3.49	1.32			1

*** Correlation is significant at the 0.001 level (2-tailed).

4.2 Independent Sample T-test

The independent sample t-test was conducted to test the difference between boys and girls in the three dimensions. As presented in Table 2, boys (M = 3.75, SD = 1.47) had significantly higher levels of STEM-related career interests than girls (M = 3.11, SD = 0.97), t (120) = 2.65, $p < 0.05$. Further analysis indicated that there were no significant differences between students' STEM interests and STEM values.

Table 2. *Independent Sample T-test*

	Gender	N	Mean	SD	*t*	Sig. (2-tailed)
STEM interests	Boy	73	3.82	1.24	0.42	0.68
	Girl	49	3.73	1.02		
STEM values	Boy	73	3.96	1.21	0.83	0.41
	Girl	49	3.79	0.99		
STEM-related career interests	Boy	73	3.75	1.47	2.65	0.01
	Girl	49	3.11	0.97		

4.3 Regression Analysis

The regression analysis was computed to test if STEM values and STEM interests predict STEMrelated career interests. As shown in Table 3, the results of the regression indicated the STEM values and STEM interests significantly predicted STEM-related career interests, $R^2 = 0.64$, $F(2,119) = 107.07$, $p < 0.001$.

Table 3. *Regression Analysis*

Dependent variable	Independent variable	Beta	*t*	Adjusted R Square	F
STEM-related career interests	STEM interest	0.30	3.07***	0.64	107.07***
	STEM value	0.54	5.63***		
	STEM value	0.54	5.63***		

*** Correlation is significant at the 0.001 level.

5. Conclusion and Discussion

This case study showed that there was a significant relationship between STEM values, STEM interests and STEM-related career interests before secondary students were exposed to our STEM education program. Therefore, educators and program designers can cast more attention on the promotion of STEM values and

STEM interests in order to achieve the purpose of promoting students' willingness to pursue STEM careers. Studies have shown that students' attitudes toward STEM have important potential for interest in future STEM careers (LaForce, 2017). Students' attitudes toward STEM careers tend to be stable and level in middle school, which is related to their future STEM careers (Wiebe, 2018). The results of the survey showed that gender had a strong correlation with STEM-related career interests, and girls had relatively low STEM-related career interests. Previous studies have also reported that girls are less likely to choose STEM careers in the future, despite having equally important potential in STEM fields (Ünlü & Dökme, 2020). In the future, we will further study how to promote girls' motivation in pursuing STEM careers.

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Four-bar Linkage Quadruped Biorobotic Instructions: Gamified Design and Development

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Abstract:
STEM education are embedded into formal education in many secondary schools around the world since students need to understand electrical and mechanical principles as well as computer controls to solve future life problems. In order to enable students to absorb the knowledge more effectively and be more curious about these knowledge, this study proposed a gamified hands-on four-bar biorobotic instruction by teaching the knowledge of linkage mechanism. Four-bar linkage biorobotic require mechanical thinking that emphasizes on balance, free movements, speed, and potential connections to computerized interactions. Through trials-and-errors, students use adjustable skeletons created by 3D printing technology that allows the effect-testing of the various ratios of the connecting rods, which are connected with a DC motor and Legos to enable remote computer controls. This paper not only introduces the design of the biorobotic instruction for junior high school students but also introduces the application possibilities and future studies for this development.

Keywords:
Biorobotics, four-bar linkage, linkage mechanism, 3D-printing, gamified instruction

1. Introduction

STEM education are embedded into formal education in many secondary schools around the world, especially Taiwan, since students need to learn the basic principles of mechanics, electronics, and technology at the same time to strengthen the computational thinking skills (Selby & Woollard, 2013) such as problem solving and logical analysis. The main purpose of this study is to design a four-bar linkage quadruped biorobotic instruction for use in the life science and technology class of Taiwan's junior high school curriculum. In order to make the robot easy to use, simple to assemble, and easy to learn for the students, LEGOs were used as the leg part in this research. LEGO has high variability that allows the development of creative quadruped robots. Although LEGO linkage bionic robots already exist, it requires a LEGO motor and LEGO EV3 controller to program. Not only it is more expensive, most robotics do not mimic real skeleton structure of quadruped animals, such as horses.

Therefore, this study proposes the biorobotic instruction to start with the principles of the linkage mechanism, so the biorobotics can be driven by simple DC motors. There are three parts of quadruped biorobotics, including a DC motor, legs using LEGO parts, and a skeleton that link the previous two. This paper presents an instructional design of the quadruped biorobotic instruction with hands-on linkage mechanism lessons and gamified activities with simple block programming. Computational thinking in both programming and problem-solving are included to prepare students for facing future problems.

The difference between this curriculum and the Taiwan cram school is that students are taught how to assemble robotics using standardized manuals with extensive hours on achieving highest speed and accurate paths. On the other hand, the LEGO camps stress on creative assembly of parts and components. With combined goals, this curriculum extends its emphasis on the fundamental understanding of biorobotic skeletal structures and movement mechanisms so students' creativities can be presented in the making process. Such instruction not only integrate interdisciplinary literacy of biology, science, mechanical engineering, and technology, the cultivation of students' independent research skills for tackling problems with mechanical and technological resources are practiced so students are more prepared for solving future problems.

2. Related work

2.1 Biorobotics and linkage mechanism

Biorobotics is a kind of robotics that imitate a living creature in terms of biological forms and mechanical structures. There are various kinds of bionic robots, such as bionic birds (e.g., Pan et al., 2021), quadruped bionic robot (e.g. He & Gao, 2015), bionic fish (e.g. Yan et al., 2022), bionic reptiles (e.g. Li et al., 2022), and so on. The cost of building a bionic robot is generally high, and the use of a linkage mechanism can reduce the number of motors to lower the cost. Among which quadruped bionic robots are the more common biorobotics. There are several existing kinds of linkage robot leg designs, such as Jansen's 12-linkage mechanism (Patnaik & Umanand, 2016) which can be difficult for students without basic knowledge. Thus, this study focuses on the development of four- bar linkage bionic robots that allows students to learn the linkage mechanism and its related creations. There is little recent research on four-bar linkage mechanism leg designs, especially for the education of the younger generation.

2.2 3D printing: materials

In order to provide students durable components in low cost, and the materials used for 3D printing should be tough, relatively inexpensive, and environmentally friendly. There are many kinds of 3D printing materials, such as PLA, ABS, and PETG. PETG is the most environmentally friendly material, while ABS is the least one (Kumar et al., 2022). Comparing to PLA, PETG is superior in terms of toughness, relatively transparent, and equal cost (Popa et al., 2022). For easy access and low cost, PLA is chosen to be printed using fused deposition modeling (FDM) 3D printers.

3. Biorobotics Instruction

3.1 Four-bar linkage leg design

There are two-leg designs of the four-bar linkage biorobotics known as: cross-shaped and M-shaped four-bar linkage biorobotics (Figure 1). The cross-shaped design is the double-rocker linkage mechanism, and M-shaped is the crank-rocker linkage mechanism. This study designs a kit (Figure 2) so that students can use the components in the kit to assemble the two designs of leg structures. The skeletons come with holes to allow versatility for structure design and to test the effects of different length ratios.

This kit mainly provides a skeleton that allows the DC motor to combine with LEGO. LEGO parts are replaceable with other objects for variations of products. Using 3D printing skeletons allow us to use general DC motors instead of EV3 to reduce cost. A kit for this proposed instruction (Figure 2) cost less than $5 U.S. dollars. The same low-cost kit can be assembled with other Lego parts to creation various kinds of final projects; for example, with the addition of Lego pulleys, students can make cranes; with the addition of fan blades, students can make windmill or boat. This kit has high variability and high availability as teaching aids at very low cost.

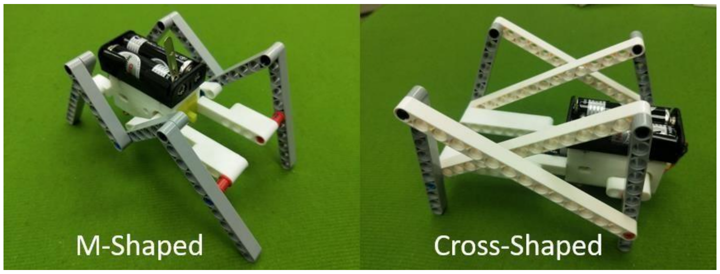

Figure 1 M-Shaped and Cross-Shaped four-bar linkage biorobotics

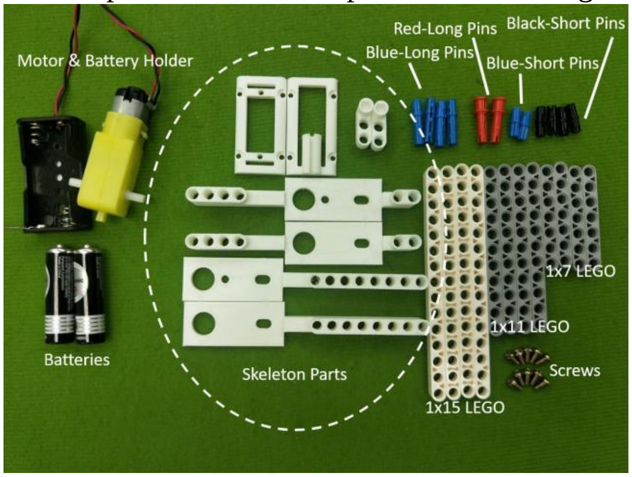

Figure 2 Four-bar linkage biorobotics kit

To prepare learning materials, SolidWorks is used in this study to draw the skeleton, which are saved as STL files which are native to the stereolithographic CAD software created by 3D systems. Then, the slicing software Cura is used to turn the 3D drawing into a gcode file that can be read by a 3D printer (Figure 3). A set of materials for one biorobotics requires approximately seven hours to print excluding failure printings. Nevertheless, the long start-up preparation can produce high cost- value teaching project materials.

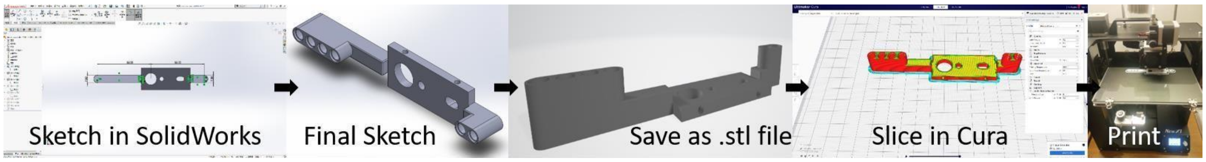

Figure 3 3D printed skeleton making process

3.2 Biorobotics skeleton design

The design of the skeleton is divided into upper cover, lower cover, left bar, and right bar (Figure 4).

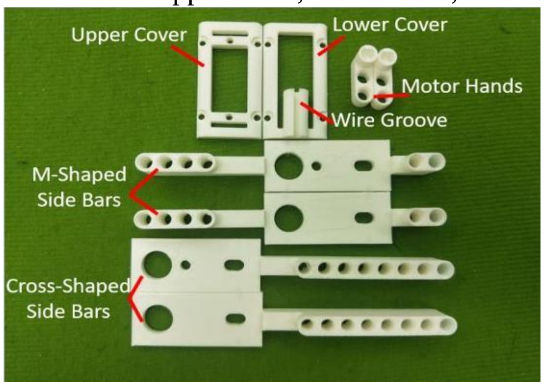

Figure 4 Skeleton Parts

The design of the upper and lower cover is not only used to combine the left and right bars, but the upper cover also added screw holes to attach the battery holder, and the lower cover adds a groove to hide the wires to prevent the robot from tripping over the wires when walking. There are two types of left and right bars, one is designed for assembling M-shaped and the other is designed for assembling cross-shaped. Four parts surround the motor and are screwed together to form a motor holder. The pole part of the skeleton has many holes dug in it for connecting LEGO and allows students to decide the length of their biorobotics. The developed biorobotic kit was tested on two master students, both of whom have no mechanical background and did not receive the M-shaped leg assembly instruction. However, both students were able to assemble and improve three generations of biorobotics within two hours, and one of them made an M-shaped four-bar linkage leg design and the other one made a cross-shaped four-bar linkage leg design. With detailed instruction and help from the teachers, it is believed that the junior high school students could also design at least three generations of biorobotics within two hours. This idea will be tested in the future.

3.3 Instructional Design

The instruction can be either implemented into formal education which requires two class period or practiced as a half-day summer camp activity (Figure 5). The content includes a) the introduction to linkage mechanism; b) M-shaped biorobotic assembly; c) hands-on practice; d) gamified assessment;
e) reflection and showcase. Learning sheets are used to guide students through the course, besides to enhance their understandings of the course content, their learning processes are documented as learning profiles. In summer camps, teachers can take more time to cover additional topics, go into more details about course content, show exemplary products, or allow students to use block programming to mobilize their robots once they are done. The instructional process is as follows.

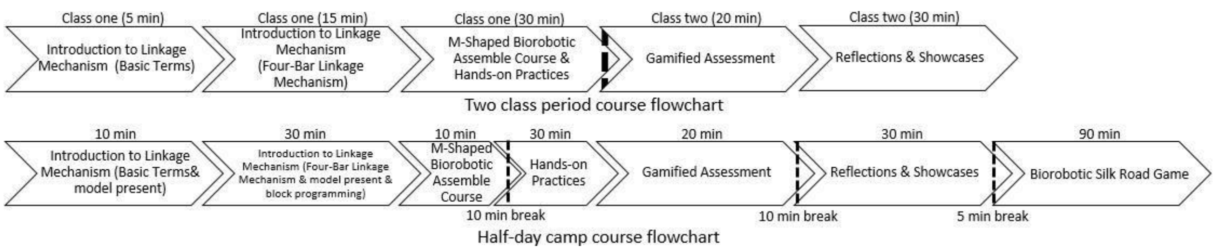

Figure 5 Course flowcharts

a) The introduction to the linkage mechanism. This section introduces the basic terms, definitions, and applications of M-shaped and cross-shaped linkage mechanisms. Examples are shown to illustrate the use of linkage mechanisms, such as M-shaped is used in bicycle and cross-shaped is used in windshield wiper.

b) M-shaped biorobotic assembly. To demonstrate the basic assembly and layering concepts, teachers guide the students step-by-step assemble of a basic M-shaped biorobotic so that students can have sufficient knowledge on how to assemble a biorobotic and know about the possibilities to improve it.

The following explanation use M-shaped skeleton as the example. Figure 2 shows parts of the M- shaped. To assemble the skeleton, first, attach the two M-shaped side bars on to the motor and screw in the upper and lower cover (Figure 6a). After finishing the skeleton, tug the battery holder wire into the wire groove of the lower cover (Figure 6b), and screw the battery holder on the upper cover to install the battery (Figure 6c). For the leg part assembly method, first of all, install the motor hands on the motor and install it in the opposite way on both sides, then install the red-long pin into the end of the longer end of the skeleton, and install the blue-long pin into the end of the shorter end of the skeleton (Figure 6d). Next, install the blue-short pins into to the red-long pins (Figure 6e), then the pins can be connected to 1x11 LEGO as a foot (Figure 6f). Then, install a 1x7 LEGO with blue-long pins and motor hands together (shown as Figure 6g), and then in the other end of the blue-long pins connected to another 1x7 LEGO as part of the knee (Figure 6h), and finally using four black-short pins to connect the 1x7 and 1x11 LEGOs together to complete the M-shaped four-bar linkage biorobotic assembly (Figure 6i). After finishing the assembly, the students are ready for the upcoming hands-on section. During the hands-on practices, the students can choose from the M-shaped or the cross-shaped skeletons to assemble and elevate their design.

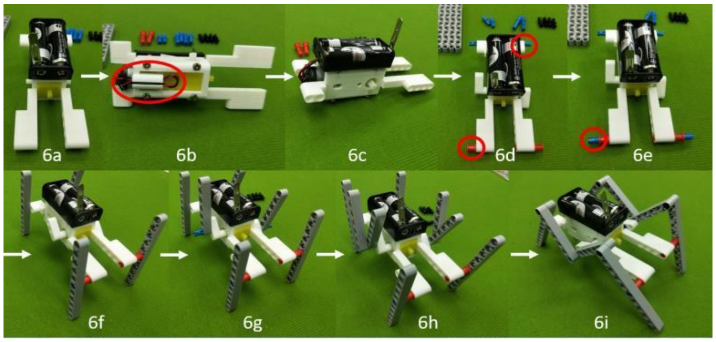

Figure 6 M-shaped four-bar linkage bionic robot assembly

c) Hands-on practice. Students test their own design with chosen linkage mechanism, investigate and improve their own assembled biorobotics. They document the use of length and ratio of rods, motions, balances, and speeds of every trials of their biorobotics on their own learning sheets, and use it to review and compare their different effectiveness.

d) Gamified assessment. An in-class competition will be conducted wherein individual students test their biorobotics, modify them, and perfectionize them. The competition is based on a ranking system with repechage to give student the opportunity to showcase their works.

e) Reflection and showcase. Students show their final biorobotics to the whole class with their design concepts, and the analysis of their strengths and weaknesses. The learning sheets are used to review students' understandings to the linkage mechanism, creativity, and effectiveness of the makings.

f) Interactive game. Additional gamified application can be added in the summer camp.

In this study, a Biorobotic Silk Road Game is designed for a whole-class interdisciplinary interaction. A 4m x 4m room-size map of the ancient Chinese Silk Road is displayed on the floor. Students are divided into groups of four and play various ethnicities in the historical scenario. Students in each group takes on different roles such as commander, warrior, trader, and diplomat. The commander is responsible for strategic directing the entire team who has the highest decision-making authority and speaks on behalf of their group. The warrior plans the wagon's route and writes block programming to operate the biorobotic horse carriage which may involve in communications and battles. The trader is responsible for executing all transactions and management of funds, goods, and treasures. The diplomat is responsible for negotiating with other groups and reaching competitive agreements.

The Biorobotic Silk Road Game has several stages, each of which is based on a historical event with conflicts and tasks. The commander needs to observe the situation and guide the discussion to make action decisions. The diplomat then goes on to negotiate and solve problems. Only after the conflicts are resolved can the warriors program the biorobotic wagon to move to the designated location on the map to either look for trading opportunities, battling for defense or expand territories, or spreading out their cultural impacts. The geographical restrictions of the Silk Road routes must be observed, calculated, and planned so that they can move freely across the land. According to traffic rules, wagons will slow down when crossing the mountains and should reduce loads while crossing the deserts. Once the warrior has successfully driven the wagon to the designated location, the trader oversees and performs trading. When playing the Biorobotic Silk Road Game, students can learn and apply mechanical, electrical, geographical, and historical knowledge and skills in the half-day camp to achieve interdisciplinary learning.

4. Conclusion

4.1 Application possibilities

Although we don't often hear the term linkage mechanism, it is found in every corner of life, such as bicycles, car wipers, and factory machines, which often use the principle of linkage mechanism. Therefore, learning the basics of linkage will help us to have a better understanding of the objects we use in our lives. In fact, in Taiwan's education, the basic linkage is taught in life science and technology classes in junior high schools, and the linkage mechanism is also taught in the mechanical department of senior high schools, and the linkage course is also taught in many summer camps. If the robots are combined with a large map learning board game that incorporates geography and history, it can achieve interdisciplinary learning. For example, Biorobotic Silk Road Game. Students write block programming to control a biorobotic to specific locations to complete tasks and to learn when playing. In fact, the biorobotics developed in this research will be used in a learning activity of quadruped biorobotics, which includes knowledge teaching of linkage mechanism, DIY biorobotics, and simple block programming courses (Chen & Shih, 2022).

4.2 Future related studies

This linkage biorobotic is only the first generation of this robot, there can be more kinds of changes and research to be done. In the future, it will be combined with a large history education board game, allowing students to play with the robot in a large map, which allows students to first learn mechanical principles and block programming, then by applying it to control the biorobotic horse to certain places on the map to accomplish missions to learn multiple disciplines at the same time. Through the process of playing, students will learn the basic knowledge of electronics, electrical, mechanical, history, geography, etc., which is interdisciplinary learning. It will also be applied in STEM/STEAM education courses, allowing students to learn mechanical principles by assembling their own linkage biorobotics, and analyzing the students' building process through the records. Finally, we hope that future research and teaching will be more interesting and in-depth.

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Leveraging IEC and Others' Viewpoints Presentation to Foster Breeding of Creative IoT Gadgets

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Abstract: This paper proposes a MESH blocks based creative thinking support system equipped with others' viewpoints presentation feature. The recent hype around digital transformation (DX) fueled a growing sense of expectation for innovation, which requires flexible thinking and rich creativity. On the other hand, others' viewpoints are believed to hold clues for discovering new insights. Therefore, the present study aims at catalyzing creativity through adaptive presentation of context relevant viewpoints from others, as hints for idea breeding. Experimental evaluation results confirmed that the system was able to promote acquisition of new ideas which users did not have beforehand. In addition, we found that the system was able to generate MESH programs that subjects could not have come up with on their own.

Keywords: Creative thinking support system, Perspective-taking, STEAM education, IEC

1. Introduction

In recent years, digital transformation (DX) has been increasingly expected to change people's lives for the better. DX requires innovation, which demands originality based on sensitivity and intelligence, as well as creative thinking to generate many ideas. However, there is a limit to how many ideas one person can come up with instantly when prompted with a task. One solution for this problem is to help people generate ideas by acquiring others' viewpoints, which could raise awareness on different way of seeing and feeling things. The acquisition of others' viewpoints can be a clue to new insights and discoveries and is expected to be effective in supporting insight into ideas that are discarded due to differences in values (Ichikawa et al., 2008).

As one of the attempts to support people's creative thinking, idea support systems using computers (Orihara et al., 1993) have been proposed. One approach for supporting creative thinking with these systems is a so-called "interactive idea support", in which support is provided based on human evaluations (Sugiyama et al., 1991). The displayed contents and evaluation method are important for systems using this approach, and they need to be designed so that users' creativity can be fully exercised. Therefore, such approach requires the optimization of the display contents based on human sensibilities.

Interactive Evolutionary Computation (IEC) is one of the methods for creating products or artifacts that match human sensibilities through human-computer communication. IEC optimizes the system towards providing outputs that are consistent with the user's evaluation (Takagi, 2001). Research leveraging IEC-based idea generation has been conducted to achieve optimization based on user's sensitivity. As an example, an idea support system using Augmented Reality (AR) with an IEC driven optimization approach has been proposed (Furukawa et al., 2021). This system supports users' ideas through programmable IoT blocks called MESH blocks. The system displays virtual MESH programs, using AR to suggest the relevance of MESH programs and attached IoT sensors and objects. Finding relevance in things helps creating new value, hence using AR technology is considered to be effective in supporting ideation (Rosello et al.; 2016, Fuste et al., 2019).

In this study, we propose a MESH blocks based creative thinking support system which is equipped with AR technology and most importantly a context relevant others' viewpoints presentation feature. The proposed system supports new ideas creation through adaptive presentation of other users' perspectives (i.e., evaluation reasons), in addition to dynamic optimization of displayed MESH programs using interactive genetic algorithm.

2. Related Works

Creative thinking is a way of thinking that enables one to come up with new solutions from a state in which one does not have knowledge or necessary experience to solve the problem (Inaba et al., 2004). Thus, creative thinking consists of divergent thinking, which is the creation of numerous and varied ideas and flexible thinking without being bound by preconceived ideas, and convergent thinking, which is the selection of ideas that are useful for solving a problem from many and summarizing them in a deliverable fashion. That is, creative thinking is the act of seeking a better approach to a given task as a solution by viewing it from multiple perspectives and creating a variety of ideas based on flexible thinking.

Generally, acquiring others' perspectives is considered as the ability to understand how a matter is evaluated from others' standpoint, upon noticing differences between one's and others' viewpoints (Tanaka et al., 2013). For instance, in cognitive science, it has been suggested that projecting ideas of others with different viewpoints in problem solving can lead to serendipitous discoveries and creative solutions (Oehlmann, 2003; Morita, 2005). Kusunoki argue that it is necessary to create a framework for deepening one's own thinking from the viewpoint of conflicting others' ideas in cooperative learning (Kusunoki et al., 1999). In the same vein, Takeda suggests that others' viewpoints deepen creative thinking and contribute to the diversification of thinking (Takeda, 2020).

Thus, creative thinking through contact with others' viewpoints is suggested to be a trigger for making new discoveries and deepening one's own thinking.

Interactive Evolutionary Computation (IEC) is a generic term which refers to a group of optimization techniques or algorithms that uses subjective human evaluation instead of a numerical fitness function to perform search (Takagi, 2001). IEC can be seen as a computation paradigm that leverages human sensitivity to solve optimization problems where the fitness function cannot be assumed or appropriately represented in the form of a mathematical function. For instance, the use of IEC techniques has been successful in many areas, such as fashion design (Lee et al., 2001), music composition (Tokui et al., 2000), aid hearing aid fitting (Takagi et al., 2007), where optimization results should address users' preference.

In this study, we use an Interactive Genetic Algorithm (IGA), an IEC technique, which embeds human subjective evaluation into a traditional genetic algorithm. Because the user's subjectivity is reflected in the degree of solution optimization achieved by the algorithm, IGA is often used to solve problems that require sensory and intuitive human evaluation, making it ideal for the purpose of the present study.

3. Creative Thinking Support System

On the lights of the aforementioned studies, the present work aims at leveraging interactive evolutionary computation to achieve a creative thinking support system which presents relevant others' viewpoints as idea breeding hints that are optimal for users. Through the adaptive presentation of divergent perspectives or point of views from others during the idea generation process, the proposed system is expected to foster users' divergent thinking, thereby helping them come up with novel ideas that they could not have conceived on their own (i.e., convergent thinking). To this extent, we implemented an augmented reality (AR) based prototype system where users are instructed to design original MESH programs by combining visual coding and real word objects. In the next paragraphs, we provide a brief overview of the key components of the proposed system.

3.1 Creative Thinking Task

We designed a creative thinking task which enables users to follow their creativity and build gadgets using MESH blocks. MESH is a tool that allows users to realize various ideas by programming the combination of familiar objects and functions such as sensors and switches (MESH, 2021). The MESH blocks shown in Figure 1 can be easily programmed by drag-and-drop using MESH app on an iPad or Windows PC. Various conditions, including movement, brightness, and humidity, can be detected by each block. These can then be programmed in the MESH app and attached to any everyday object.

Figure 1. MESH Blocks and MESH app interface.

Figure 2. An Example of MESH Program.

In this study, physical IoT blocks such as motion sensors are called "MESH blocks", while MESH blocks and other functions that are manipulated on the MESH app when programming are referred to as "MESH tags". For example, in Figure 2, the MESH tags are combined and programmed on the MESH app to create a program that "waits for a few seconds when the motion sensor detects a person and then plays a sound".

Moreover, in this study, MESH tags are classified into INPUT tags, LOGIC tags, and OUTPUT tags. INPUT tags are ones that function only as inputs to other tags, LOGIC tags are ones that function as logical operators such as "and", "or", and the remaining tags are classified as OUTPUT tags. Note that the use of such IoT devices is also intended to frame the present contribution in a STEAM Education context, which is an educational approach that connects problem-solving to real-world situations, thereby inspiring students' inquiry and curiosity and promoting creativity and exploration.

3.2 Interaction Interface and Presentation of MESH Programs

To let users freely visualize and interact with objects in the AR based interaction environment, we used HoloLens2, a head mounted display developed by Microsoft (Hololens2, 2022). HoloLens2 embeds a hand tracking function which allows tracking movement of the 10 fingers of the wearer. Furthermore, HoloLens2 supports high-precision spatial recognition, allowing users to intuitively manipulate digital content by grasping it with their hands. Users can also move around in real space and use both hands freely while viewing digital information, since it is head-mounted and operates wirelessly.

To start with, based on the selected motion blocks and tags, the system generates some MESH programs that the user is required to evaluate. Then, the system optimizes the MESH programs based on the evaluation values entered by the user and generates the next generation of candidate solutions. Note that in order to achieve generation and optimization of candidate solutions, IGA, a type of evolutionary computation, is used, as explained in section 2.2. Note that since there is only one MESH block of each type, if the same MESH tag appears more than once in the generated program, it is randomly replaced with another MESH tag.

Next, individuals similar to the generated solution candidates are extracted from the database and presented to the user. The database stores MESH programs highly evaluated by other users, to which are attached the evaluation targets, as well as evaluation reasons. The evaluation targets are MESH blocks, tags, and objects that were the decisive factors for the evaluation, and the evaluation reasons are the rationale for highly evaluating a given MESH program. When extracting individuals from the database, the system extracts individuals that have not been presented to the user yet.

4. Pilot Study

4.1 Outlines

To the extent of investigating the meaningfulness of the proposed system, we carried out an experimental evaluation in which subjects were asked to refer to others' perspectives (i.e., evaluations targets and reasons) while evaluating generated MESH programs. Participants were 12 male and female

Figure 3. Experiment Scene.

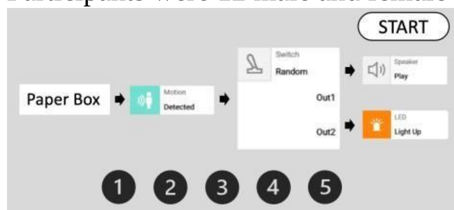


Figure 4. Evaluation Interface.

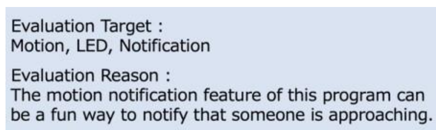


Figure 5. Example of Evaluation Reason.

students attending a Japanese university. A typical experiment scene is shown in Figure 3 and the evaluation interface is shown in Figure 4. Note that subjects are presented with others' perspectives only after inputting a low or medium evaluation score towards the system generated MESH program. That is, if the subject evaluates the presented MESH program highly, the subject is not requested to refer to others' perspectives. Figure 5 shows an example of evaluation reason left by another user.

Table 1 shows the questionnaire items used in the evaluation experiment. The questionnaire items were rated on a 5-point Likert scale going from agree / slightly agree / neither / slightly disagree to disagree. In addition, a free-writing section was also included so as to collect subjects' opinions on the system.

Table 1. *Questionnaire Items.*

Number	Question
Q1	Were you able to find ideas that you didn't have by referring to others' viewpoints?
Q2	Do you think the proposed program broadened your thinking (i.e., divergent thinking)?
Q3	Did the system present you with programs that you might not be able to come up with on your own (i.e., convergent thinking)?

4.2 Results and Discussions

From the results of the questionnaire, we discuss whether the acquisition of others' viewpoints using the proposed system contributed to the design of original IoT programs inspired from ideas that subjects did not have beforehand. The questionnaire results are shown in Figures 6-8.

Q1 asks whether the presentation of others' perspectives during evaluation of various MESH programs, contributes to supporting subjects' creative thinking. We found that 85% of the subjects answered "agree" or "slightly agree" to Q1, and the remaining 15% answered "slightly disagree". This indicates that presenting others' viewpoints supported subjects' creative thinking.

Q2 and Q3 ask whether the MESH programs generated by the system contributed to prompt subjects' divergent and convergent thinking. Here, 100% of the subjects answered, "strongly agree" or "agree" to Q2, and 92% answered "strongly agree" or "agree" to Q3, while 8% answered "neither agree nor disagree". These results indicate that the proposed system was able to generate MESH programs that subjects would not have thought of, and that it might be an effective tool to encourage both divergent and convergent thinking.

Figure 9 shows the average evaluation scores of all subjects for the MESH programs generated by the system. The evaluation scores were mainly divided into high and low evaluations. The low evaluations were categorized into "positive change", "no change", and "negative change" based on the evaluation values before and after the reevaluation. A "positive change" is defined as an increase in the evaluation value after the reevaluation compared to the value before it. For example, a case a subject puts a rating of "3" and then changes it to "5" after reevaluation, is considered as a "positive change".

"no change" indicates that the evaluation value after reevaluation is the same as before reevaluation, and "negative change" indicates a decrease from the value before reevaluation.

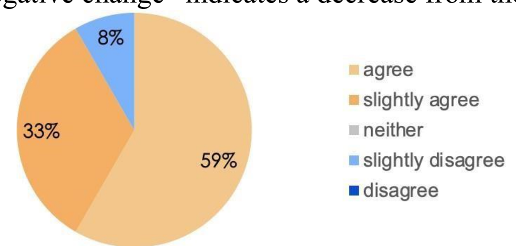


Figure 6. Q1 Questionnaire Results.

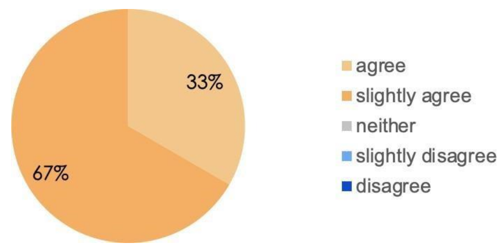
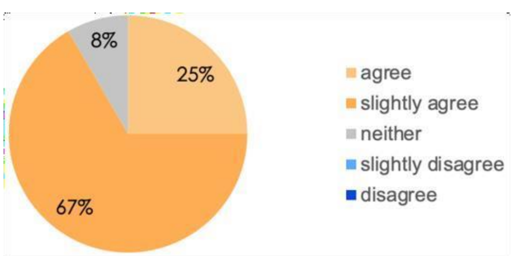


Figure 7. Q2 Questionnaire Results.



Q3 Questionnaire Results.

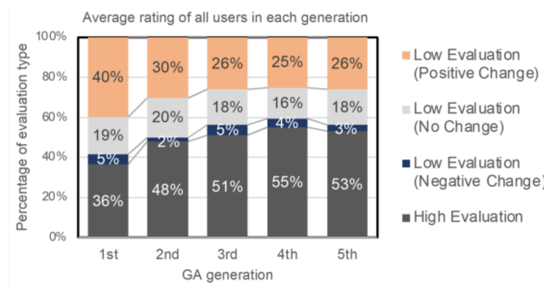


Figure 9. Evaluation Results of *Figure 8.*

Generated MESH Programs.

In Figure 9, we can see that the number of high evaluations by the subjects increased from the 1st to the 4th generation, before decreasing around the 5th generation. This might be due to the presentation of MESH programs reflecting perspectives that are different from the subjects' viewpoints. In addition, when subjects gave low evaluations to MESH programs, the percentages of subjects who changed their evaluation values before and after reevaluation were 70%, 62%, 63%, 64%, and 62%, respectively from the 1st generation to the 5th generation. Thus, in all the generations, more than 60% of the evaluation scores were updated. This can be seen as evidence that the creation and generation of MESH programs and the presentation of the reasons for others' evaluation by the proposed system could be effective in prompting diverging thinking among subjects.

In sum, from the above results, we confirmed that the proposed system is able of generating MESH programs that subjects could not have come up with on their own (i.e., convergent thinking), by adaptively presenting subjects with others' viewpoints, which might have contributed to broaden their thinking.

Moreover, in the free-writing, we received comments such as "I thought it would be more convenient if the proposed system could have a social media-like feature, making possible to instantly exchange reasons for the high evaluation to others". On the other hand, some subjects also mentioned few issues such as: "As the generation evolved, the proposed system presented MESH programs similar to the ones I already evaluated" and "I didn't change the evaluation value because the reasons for others' evaluation that I referred to were not written in detail and seemed to be the same to my own idea". From these feedbacks, we understand that the proposed system sometimes failed to present MESH programs that were not similar to the programs previously evaluated by the subjects. The lack of extensive accounting of the degree of difference between subjects' own perspective and presented others' perspectives might also be a shortcoming. Therefore, future works will be dedicated to address such issues.

5. Conclusion

Fostering creativity is not an easy undergo as it requires to prompt both divergent and convergent thinking. In this study, we proposed and implemented a creative thinking support system by embedding an others' viewpoints presentation feature in a MESH program optimization system. Then, we conducted an experimental evaluation to examine the effectiveness of the proposed system.

We found that presenting others' viewpoints can support the breeding of new ideas among the system' users and make them change their mind (divergent thinking) on the value of MESH programs they low-rated at first sight. In addition, we found that by interactively collecting users' preferences (evaluation scores), the system was able to optimize (convergent thinking) original MESH programs which users admitted they could not have come up with only by their own.

In future works, we plan to improve the performance of the system so that it can generate and present MESH programs that are not similar to those already evaluated by users, and present others' viewpoints that essentially differ from users' current perspectives.

Acknowledgements

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Enhancing Students' Interest in STEM-Related Subjects at Omani Post-Basic Schools through Application of Augmented Reality

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Abstract: With the goal of preparing students to be competent employees with a range of abilities, including critical thinking and problem solving, STEM education is a demanding trend. To encourage students to pursue this field of study, there is a need to address the low interest in STEM-related subjects. One of the innovative technologies, augmented reality (AR), has the potential to increase students' interest in studying STEM-related disciplines. It is important to study how this technology could increase students' interest in STEM-related subjects in Oman because the application of the technology is rather new-fangled. This paper presents a proposal to explore students' preparedness and acceptability for an effective implementation of AR technology and how AR triggers, immerses, and extends their interest in studying STEM-related subjects. This study is expected to contribute to knowledge by proposing practical AR application in post-basic schools in Oman.

Keywords: Augmented reality, STEM education, interest

1. Introduction

Countries around the world encounter challenges to create qualified generations contributing to enhance their economy. Therefore, the need for qualified graduates in Science, Technology, Engineering, and Mathematics (STEM) is highly demanding (Atkinson & Mayo, 2010). Research has indicated that STEM education is evolving internationally (Li et al., 2020). This is because governments globally are seeking to fulfil students' shortcomings in terms of practical skills that enable them to be a significant factor in their economy.

In line with the Oman Vision 2040, Oman wants to bring innovation and advanced technologies in its education sector to produce quality graduates (Oman Vision 2040 Committee, 2019). Also, the government emphasizes the importance of studying science subjects – i .e. biology, chemistry and physics and pure mathematics – as elective subjects in grade eleven and twelve. This demands preparing students from early stages. Subsequently, MOE launched the Cambridge International Chains of Science and Mathematics Curriculums in 2017 in government schools.

However, the annual statistics book issued by the Ministry of Education (MOE) in 2019 showed that the number of students who chose science subjects constitutes 33% only of the total number of students in post-basic Omani schools (Ministry of Education, 2019). Furthermore, according to the Trends in International Mathematics and Science Study (TIMSS) 2015, in both grades four and eight, students' interest towards science and mathematics has decreased. Nearly three-quarters of Omani students, and more than half of the international average of 56%, like learning science in fourth grade. However, the trend is different for grade eight students. Approximately half of Omani students like learning science, compared to the international average of 37% (Ministry of Education, 2018). This reveals that interest in studying science subjects declines gradually with school years (De Lepe et al., 2015; Potvin & Hasni 2014). This explains why maintaining students' interest in studying science is important.

During the emerging technologies era, literature in educational technology suggest that modern technology such as augmented reality (AR) could be effective to enhance students' interest, improve students' success, increase engagement and involve students in activities (Sırakaya & Alsancak Sırakaya, 2020; Wang et al., 2018). However, teachers in Omani schools were reported still using conventional educational technologies such as photos and videos as teaching aids in their classes (Ministry of Education, 2019). The students also seem to show lack of interest in these technologies (Al Rajhi, 2016). With this regard, this study will focus on exploring in what ways AR can be used to enhance Omani students' interest in STEM-related subjects.

2. Literature Review

2.1 The Concept of Augmented Reality (AR)

AR is an emergent technology that has been implemented in different areas in our life. Azuma (1997) supposed that AR is one of the frequently used concepts that allows users to see virtual objects and digital information overlaid on the real world. It is perceived that AR does not replace reality but combines and enhances it. Based on this definition, three features of AR are specified that it integrates physical and virtual, real-time immersive and 3D-registered. Students' perception is not isolated from teachers' perceptions in terms of the use of AR in learning STEM-related subjects. A study conducted by Soo et al. (2019) aimed to determine students and instructors perceptions towards the use of AR revealed positive perceptions by both of them. Students' positive views represented by the interactive characteristics and features of AR. In addition, students became excited as AR technology is novel and interesting. This positive view also was pointed out by Sahin & Yilmaz (2020) in their study that students were pleased about the use of AR in learning science subjects and want to continue using it in the future.

However, in another study, students indicated that they needed more time to use AR and found it a bit uncomfortable in comparison to a conventional lesson (Soo et al., 2019). Research has also indicated controversial views regarding the use of AR from students' perceptions (Akçayır & Akçayır, 2017). In their study, they pointed out that AR to be complicated to implement, while others found it to be beneficial. Therefore, in this case, it would be better to explore the potential of AR in Omani context which will create a clear picture about its uses and accessibility in school contexts and open up a door to stakeholders to take future actions to its implementation.

2.2 Interest Development in learning STEM-related subjects

Interest is viewed by Dewey (1913) as motivating forces underlying meaningful learning that are more powerful than effort alone. In this case, students' persistence does not stand alone in fostering student' learning without interest. He added that it is impossible to separate an interest from an object. This is because interest is considered as a major element in students' learning (Wong et al., 2020) Therefore, interest is a state of mind described by a desire to focus one's concentration on something meaningful to them, such as an activity, a goal, or a subject (Hidi & Renninger, 2006; Regan & DeWitt, 2015). This was ensured Students' interest for STEM-related subjects has a significant impact on whether they persist in their desired stream or convert to an art career trajectory. Sanders (2009) pointed out that, in order to combat the 'STEM pipeline' problem effectively, we ought to discover techniques to involve young learners' interest in STEM education during their school years. Krapp & Prenzel (2011) also emphasized that interest as a prerequisite for science education, as well as a method and goal of science education, remains a significant issue for contemporary academic system.

To develop students' interest in learning STEM-related subjects learning, instructors need to adopt different approaches such as four-phase model of interest development (Hidi & Renninger, 2006), a person-object theory of interest (Krapp, 2002) and flow theory (Csikszentmihalyi, 1990). These approaches and models have been adopted by many scholars to examine the development of students' interest. In this study the researcher will underpin his study by a current theory called Interest-driven Creator Theory (IDC).

2.2.1 Augmented Reality and STEM Education

AR technology contributes in enhancing students' cognitive and affective learning domains in STEMrelated subjects such as science (Yildirim, 2020). Therefore, students are pleased about learning these subjects enabled by AR because of its positive impact that make learning science easy and enjoyable (Sahin & Yilmaz, 2020). AR can increase students' achievement and motivation in learning STEMrelated subjects (Estapa & Nadolny, 2015; Ibáñez et al., 2020; Sirakaya & Cakmak, 2018). It also develops students' thinking (AL-Riyamiah, 2019; Alsakrya & Alsalmy, 2020) and acquiring scientific concepts (AL-Riyamiah, 2019). Because of this significant impact, AR technology is believed could develop different areas in learning STEM-related subjects. Adopting AR in enhancing students' interest in STEM-related subjects is crucial as this technology can promote students' interest in these subjects (Chen & Liu, 2020).

2.3 Developing Students' Interest in STEM-related Subjects Using Augmented Reality

AR is a technology that contributes AR is implemented to enhance students' interest in different subjects and levels. For instance, it plays a significant role in enhancing students' interest in studying STEM-related subjects. Many reasons push students not to be interested in studying science subjects. One of these factors is the abstraction of scientific concepts that makes students put the high requirement to learn and understand them (Swensen, 2016). In this case AR technology can contribute to enhancing students' interest in STEM-related subjects (Bressler & Bodzin, 2013; Goff et al., 2018; Hsu et al., 2017; Ibáñez & Delgado-Kloos, 2018). Research also has indicated that AR enhances students' situational interest (Cai et al., 2014; Chen & Liu, 2020; Chin & Wang, 2020; Zimmerman et al., 2016).

Although there is strong empirical evidence about the impact of AR on students' interest, there is insufficient research about to obtain in-depth insights on the usage of AR in enhancing student' interest in STEM-related subjects. Ibáñez & Delgado-Kloos (2018) emphasized that to obtain a better understanding of how AR technology may enhance STEM learning, it is also a good idea to supplement quantitative measures with qualitative ones. Alalwan et al. (2020) study revealed that students find AR interesting at the beginning however, it maintains students' interest for a short period. Based on that, in-depth insights are needed to identify how AR can trigger students' situational interest and maintain their individual interest. Therefore, the purpose of this study is to explore the potential of AR in enhancing students' interest in STEM-related subjects. In Omani context, a paucity of studies have been conducted to investigate the use of AR in STEM-related subjects. These studies focused on the impact of AR technology on the acquisition of polygons and circle's concepts and spatial reasoning (Alshezawia, 2018) and on the spatial thinking improvement and acquisition of scientific concepts (AL-Riyamyah, 2018). Unlike, this study will focus on exploring its potential in enhancing students' interest in STEM-related subjects based on students' perception.

3. Research Objective

The main objective of the proposed study is to explore the potential of augmented reality in enhancing students' interest in STEM-related subjects at Omani post-basic schools. This will be studied, first by exploring the perceptions of grade ten students in the use of AR technology in learning STEM-related subjects, and second by exploring the potential of AR technology on grade ten students’ interest in learning STEM-related subjects.

3.1 Theoretical Framework

This study will use the Interest-Driven Creator (IDC) theory developed by Chan et al. (2018) as the theoretical framework to explore the potential of augmented reality in increasing students' interest in STEM learning in Oman's post-basic schools. The core assumption of IDC theory is that learning experiences enhanced by some type of technology may have a significant influence on increasing student interest. Thus, rather than concentrating on the outcome, the major goal of this theory is to understand how interest is built in learning to arrive at an expected consequence that students would enjoy and strive to acquire (Chan et al., 2018). This theory's design consists of three loops: interest, creation, and habit. In this study the focus will be on the interest loop which consists of three anchors namely triggering, immersing and extending **(Fig. 1)**.

The reason behind adopting the interest loop is in line with the purpose of the study which demands exploring students' interest in STEM-related subjects with the implementation of augmented reality technology. Another rationale is that because AR is a new technology to be incorporated in the Omani setting, it is vital to begin exploring its potential in terms of increasing student interest as a first phase rather than integrating the other two loops of IDC theory, which are the creation and habit loops.

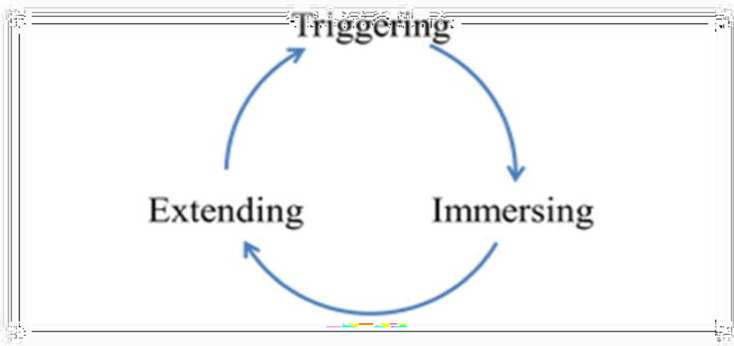

*Figure. 1***:** IDC Theory: Interest and the Interest Loop. [Adopted from Wong et al., 2020]

3.2 Research Questions

As the purpose of this study is to explore the potential of augmented reality technology in enhancing students' interest in learning STEM in post-basic schools in Oman, the following questions are outlined to guide the investigation:

1. How do grade ten students perceive AR technology in learning STEM-related subjects?
2. How does AR technology enhance grade ten students' interest in learning STEM-related subjects?

4. Research Methodology

To answer the aforesaid research questions, this study will employ a qualitative approach which is represented by a case study design encompasses on studying a case in a real and contemporary environment (Yin, 2018). An instrumental case study design type will be adopted to explore the phenomenon. This type is adopted as the case is becoming an instrument for greater understanding something else (Creswell & Poth, 2018; Fraenkel et al., 2012; Mills et al., 2012; Stake, 1995). The case is considered as a vehicle to better understand the issue (Stake, 1995). This means that the broader purpose is not to study the case itself, but to explain how AR implementation enhances students' interest to obtain an ultimate interpretation that demonstrates the phenomenon. Both observation and focus group discussion protocols will be used deductively and inductively in order to answer the research questions.

4.1 Research Setting and Participants

This study will be applied in post-basic schools that apply STEM education in Oman. These schools include grades from nine to twelve and they will be chosen purposefully. The selection of the schools will rely on particular criteria such as the adoption of AR technology by STEM-related subjects' teachers. A number of grade ten students from these schools will be selected to participate in the study. Each class consists of at least 35 students who their ages ranges between 15 to16 years old. The participants will be selected purposively based on specific criteria – i.e. taught by STEM-related subject teachers that adopt AR in their teaching, able to express their opinions eloquently.

4.2 Data Collection Methods and Procedures

Observations and focus group discussion (FGD) will be employed to collect data. Teaching Dimensions Observation Protocol (TDOP) and a self-developed observational protocol will be used during classroom visits to offer descriptive information. A semi-structured protocol also will be developed to guide the FGD. In term of the procedure, firstly, the researcher will observe students from several grade ten classes in multi-sites schools and then, selected students from the observation will be interviewed.

4.3 Data Analysis Methods

Data emerged from observations and focus group interviews will be transcribed and organised by using a computer-assisted qualitative data analysis software ATLAS.ti. After organizing the data, they will be analyzed thematically. To ensure the trustworthiness, triangulation, member check and audit trial strategies will be employed (Merriam & Tisdell, 2016). As this research is conducted to fulfil the first author's PhD requirement in Universiti Putra Malaysia and data will be collected in Oman, the research has sought ethical approvals from Ethics Committee for Research Involving Human Subjects of the university and the Ministry of education (MOE) in Oman. Students' consents will be obtained before they participate in the study to avoid any other ethical issues that might harm them such as deception and to respect their rights (Gray, 2014).

5. Proposed Contribution

This study aids to address STEM-related subjects' teachers to explore the potential of augmented reality in enhancing their students' interests in studying STEM-related subjects. The findings of the study will be beneficial for the teachers to assist them to be attentive to AR affordances that will make the learning STEM-related subjects interesting Furthermore, this will guide them how to to design and implement better teaching and learning using AR in teaching STEM-related subjects. This study will also contribute to the policy makers in making decisions to set a strategic action plan to implement AR in teaching STEM-related subjects. Additionally, curriculum designers will recognize the sorts and quality of activities that need to be included in textbooks so that instructors may utilize them to pique students' interest in STEM-related subjects.

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Support Structures and Activities for Teachers Preparing for Game-Based Learning

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Abstract: In this paper, we share the experience of teacher preparation for game-based learning by describing a series of technical, pedagogical, and content support activities that helped teachers design and implement Minecraft-based modules in their classes. The teachers made use of the What-If Hypothetical Implementations in Minecraft (WHIMC), a set of Minecraft worlds that students can explore to learn more about astronomy, geosciences, and ecology. Technical support included setting up of the WHIMC server and Minecraft accounts for teachers and students, and teacher support familiarization of the WHIMC worlds. Pedagogical support included module reviews and a dry run that allowed teachers to refine their learning modules. Content support included assisting teachers with ensuring alignment between curricular goals and WHIMC functions and features. These support activities helped teachers achieve some success in their module implementations. Additional opportunities for improvement include a separate hands-on orientation session for students and peer observation to disseminate novel pedagogical strategies. Overall, this paper illustrates how teachers need to be supported in order to prepare and deploy a game-based learning module successfully.

Keywords: WHIMC, Philippines, TPACK, Teacher Professional Development, Game-based Learning

1. Introduction

In an article published in 2011, Ketelhut and Schiffer said that technology has grown so rapidly that schools have had difficulty keeping pace. Students were adept at computer gaming, social networking, and anytime, anywhere interactions, and were able to transition from one technology to the next near instantaneously. Teachers, on the other hand, are challenged to move to the new just as they are becoming comfortable with the old. The technology type in which rapid technological change, student proficiency, and teacher hesitance are most notable is that of computer gaming. Computer gaming plays to the strengths and preferences of students but are generally underused by teachers. In the decade that followed, these observations still ring true. Games are not used extensively in the classroom because teachers have limited time to prepare, have limited knowledge of games in general and specific games in particular, struggle with designing appropriate assignments and with integrating games with curriculum efficiently and effectively (Molin, 2017; Oluwatayo, Anyikwa, & Obidike, 2020). Furthermore, schools suffer from a lack of technology infrastructure and insufficient budgets to pay for high game licensing costs (Molin, 2017).

Many of these concerns can be addressed with adequate teacher professional development programs and initiatives. However, teacher preparation for use of games in the curriculum is not something that the literature commonly discusses. Indeed, some researchers point out that there is a dearth of literature on teacher professional development on the use of games that focus on pedagogy and/or impact on professional practice (Hébert, & Jenson, 2019; Molin, 2017).

This paper contributes to bridging this gap by bringing together two themes: teacher professional development the Technology, Pedagogy, and Content Knowledge (TPACK) framework, and game-based learning. We describe how our research team in the Philippines (PH) prepared a group of teachers for the use of What-If Hypothetical Implementations in Minecraft (WHIMC) in their classes. We describe the technological, pedagogical, and content support that we provided during module development and implementation to illustrate the level of support that teachers required to succeed in their information and communications technology (ICT) integration.

2. Related Literature

This section discusses the three themes of this paper: teacher professional development, TPACK, and game-based learning. In doing so, it positions the work of this paper in the larger body of literature.

One of the determinants of successful ICT in educational practice is teacher preparation. Studies have shown that ICT professional development increases the teachers' tendency to use ICT in their classrooms (Albion, Tondeur, Forkosh-Baruch, & Peeraer, 2015; Alt, 2018; Dlamini & Mbatha, 2018). In a 2021 review of the literature, however, Hu and colleagues (2021) found that although most teachers had positive attitudes towards the integration of ICT in teaching and learning activities, they also lacked the confidence and competence to do so because they were inadequately prepared. While pre-service and in-service ICT training is available to teachers, training content is typically limited to the use of productivity tools. Teachers are taught the functions of these tools, but not how to make use of them in innovative ways (Marcial & Rama, 2015; Torii, Kamidate-Yamaguchi, & Kubota, 2019).

Training that is focused on technology rather than pedagogy often fails to translate into meaningful outcomes for students (Fernández-Batanero, Montenegro-Rueda, Fernández-Cerero, J., & García-Martínez, 2020). Ideally, teacher preparation should include training in technology, pedagogy, and content knowledge. Content knowledge refers to the knowledge about the subject matter that teachers need to teach, and students need to learn. These include concepts, theories, ideas, frameworks, and others. If teachers fail to master content knowledge, the students' knowledge will be ill-formed. Pedagogical knowledge is knowledge of the purposes and aims of education, an understanding of how students learn, and knowledge about the most appropriate methods for communicating with students. Technology knowledge refers to a mastery of ICT for communication, information processing, and problem-solving. Pedagogical content knowledge refers to knowledge of the best ways to represent and communicate the content. Technological pedagogical knowledge is an understanding of how teaching and learning change with technology, and an appreciation of what a particular technology platform can and cannot communicate well. Technological content knowledge is an understanding of how technology and content constrain each other, and an ability to choose which technologies are best suited for a specific domain.

At the center of the diagram is TPACK. TPACK is a framework described as, "the basis of effective teaching with technology, requiring an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones." (Koehler & Mishra, 2009). TPACK requires an understanding of the relationships and interactions between technology, pedagogy, and content, and how each informs the choice, use, and expression of the other.

This kind of teacher preparation cannot be achieved through one-shot workshops. Rather, teachers need continuing support and resources (Vrasidas & Glass, 2007) as well as opportunities to learn and collaborate with peers (Li, Yamaguchi, Sukhbaatar, & Takada, 2019). Exposure to inquirybased methods such as project-based learning, problem-based learning, and challenge-based learning can be particularly beneficial (Tondeur, Forkosh-Baruch, Prestridge, Albion, & Edirisinghe, 2016). They can help teachers move away from traditional modes of teacher-centric instruction to studentcentered methods that encourage lifelong learning.

One such student-centered approach is game-based learning, which is defined as "a pedagogical approach that involves the design and implementation of curricula using existing games." (Foster & Shah, 2020). Games have been shown to add value to student learning because, in addition to delivering content, they are motivational, encourage problem-solving and imagination, create a fun and relaxed learning environment. A meta-analysis of the game-based learning literature (Lei, et al., 2022) found a link between game-based learning and science achievement. Stronger effects were seen in Eastern rather than Western countries, among primary school students rather than students from high levels of education, and for interventions between 4 hours and 1 week.

However, teaching with games is not something teachers intuitively know how to do and, therefore, needs to be the subject of continuing professional development. Teachers need awareness of a game's contents, as well as its affordances and constraints (Foster & Shah, 2020). Teachers need to understand how games can be used for learning, how to plan game-based activities, how to monitor progress within a game, and how to connect the game's contents with curriculum and broader world realities (Hébert & Jenson, 2019). Furthermore, teachers need to appreciate the social, structural, and technological factors that may support or derail the successful implementation of a game-based lesson (Foster & Shah, 2020). The TPACK framework specifically has been cited as a representation of the dynamic knowledge and skills that teachers have to continuously grow in their practice of using games for teaching and learning (Forster & Shah, 2020). Without sufficient preparation and continuous growth, teachers will use games on a trial-and-error basis (Molin, 2017).

Several authors (Foster & Shah, 2020, Hébert & Jenson, 2019; Molin, 2017) have pointed out that the literature regarding teacher preparation for game integration in curriculum is sparse. Much of the existing literature tends to focus on games and their design (Hébert & Jenson, 2019). The teacher's role in designing and selecting instructional approaches, methods, pedagogy, and how teachers are supported and empowered tend to be underplayed (Hébert & Jenson, 2019; Molin, 2017). Foster and Shah (2020) point out a few studies that have focused on the process involved in teaching with games.

This paper describes how a PH team prepared and supported a group of teachers in their use of WHIMC for their science and math classes. In doing so, we hope to provide readers with an estimate of the amount of support teachers need in order to use games for teaching and learning.

3. Overview of Minecraft and WHIMC

Minecraft is an open-ended, sandbox-type video game first launched in 2009 (Bitner, 2021). It is open-ended in that it has no goal or agenda. Instead, players mine resources and craft or build new objects, often in collaboration with other players. Over 180 million copies of Minecraft have been sold to date, making it one of the best-selling games of all time. Its impact has therefore extended beyond entertainment to, among other fields, education. Over the last decade, teachers have been using Minecraft as a vehicle to teach math, science, social science, and language (Baek, Min, & Yun, 2020), as well as 21st century skills such as collaboration, critical thinking, communication, and creativity and innovation (Hebert & Jenson, 2020).

WHIMC is a set of Minecraft worlds created by the University of Illinois Urbana-Champaign (UIUC). Learners can explore these worlds as supplementary activities to learn more about science, mathematics, engineering, and technology in general. Specifically, they would learn about astronomy, geosciences, and ecology. WHIMC makes use of Minecraft's natural physics and mechanics to simulate science-related concepts. Finally, WHIMC immerses learners in simulations of conditions on certain exoplanets and on alternate versions of Earth, logging both the ways in which learners traverse these words and the observations that learners make during their explorations.

Learners first explore the Rocket Launch Facility (Figure 1), modeled after that of the National Aeronautics Space Agency (NASA). Here, learners can visit mission control and Mars rover test sites, for example, and talk to simulated NASA scientists. Then, the Lunar Base LeGuin (Figure 2) is made up of quests where learners get to learn about different experiments and research studies being done in the moon. They also get to practice measuring and recording temperature, oxygen, pressure, and wind speed. The Space Station includes an unaltered version of Earth in which learners practice making different kinds of observations. The Space Station is also the jump-off hub from which learners travel to the different worlds.

Figure 1. Rocket Launch Facility, Mission Control.

Figure 2. Lunar Base LeGuin.

The alternate versions of Earth present learners with opportunities to observe the planet under altered conditions. Although the worlds are fictional, they are created in consultation with scientists: They accurately depict conditions on Earth under these circumstances. For example, what if Earth had no moon? There would be no seasons, days would be shorter, and winds would be stronger. What if Earth had a slightly colder sun? Water might only be able to exist in liquid form in a limited strip of green, and this is where we would all be forced to live.

4. Teacher Preparation and Support

This section describes the various stages of preparation and support that the PH team provided to the teachers and their classes before module development, during module development, during implementation, and after implementation.

4.1 Technical Preparations

The PH team established a formal partnership with the UIUC team to gain access to WHIMC's content, code and configuration details. While the partnership enabled the PH team to run its experiments using the UIUC server, the team instead decided to set up its own parallel server. The UIUC server was in a state of constant experimentation and improvement. Having our own PH server allowed us to control updates, download data, provide technical support, reset progress, and so on without having to constantly coordinate with the UIUC team.

The PH team also purchased a total of 150 Minecraft Java Edition licenses which were lent to the teachers and students who were participating in the study. It was possible for teachers and students to use their personal Minecraft accounts. However, lending them PH team-owned accounts enabled us to offer students and teachers greater anonymity. Each Minecraft account was linked with PH teamowned Gmail and Microsoft-registered account. When students completed the WHIMC-related lessons, the PH team reset the passwords for each of these accounts and their quest progress in the WHIMC worlds.

4.2 Teacher Recruitment and Onboarding

The PH team established institutional partnerships with three basic education schools in the Philippines. One school had two campuses: one in Manila and one in Laguna. The other school is in Cagayan de Oro City. We asked the partner schools to nominate at least two (2) science, technology, engineering and math (STEM) teachers to participate in the study.

A total of seven (7) teachers participated in the study, five (5) females and two (2) males. On average, they had thirteen (13) years of experience teaching science and/or math at the grade school level. By the time they participated in this study, they had been teaching online for around nine (9) months because of the COVID-19 pandemic. One out of the seven teachers had an award related to ICT, which was a bronze award for Best K-12 EdTech Leadership in EduTech Asia, Singapore. Meanwhile, Three out of seven of the teachers had an ICT-related certification (e.g. Google teaching certificate, Apple Certification, Microsoft certification). A total of 276 students participated in the modules.

The PH team then scheduled a separate project briefing and planning with the teachers. During the briefing, the teachers were told about the goals of the project, an overview of the WHIMC worlds, and the tasks that they were requested to complete. The tasks included an exploration of the WHIMC worlds, module preparation, deployment, and participation in review and debriefing discussions.

4.3 Module Preparation and Review Process

The project team gave the partner teachers 30 days to explore the WHIMC worlds themselves. After familiarizing themselves with the game, the partner teachers identified specific topics within their respective academic levels' curriculum where they thought a specific WHIMC world would fit. They developed the module and submitted it to the project team, through the project manager, for initial review. Table 1 shows that teachers used the modules in a variety of ways—synchronously or asynchronously; as a supplement or as part of the main lesson. Most lessons involved inquiry-based learning, which indicates the teachers' desire to encourage students' active participation.

Table 1. Summary of teaching modes and strategies.

Teacher	Modules and Topics	Grade	Mode	Type of Integration	Strategy/ies used
1	Rocket Launch Facility: People and Places	6	Synchronous	Supplement	Inquiry-Based Learning (Guided Inquiry), Active Learning (Discussion), Visual Thinking Routine (I see/think/wonder), Use of online brainstorming board (Jamboard)
	Explore the Moon Base		Synchronous	Supplement	Inquiry-Based Learning (Guided Inquiry), Active Learning (Discussion), Use of online brainstorming board (Jamboard)
	What If the Earth Has No Moon?		Synchronous	Supplement	Inquiry-Based Learning (Guided Inquiry), Active Learning (Discussion),
2	Tilted Earth	6	Synchronous	Supplement	Inquiry-Based Learning (Guided Inquiry), Active Learning (Discussion), Venn Diagram
	Exoplanets – Kepler 186f, Gliese 436b, Cancri 55e and Trappist 1e		Synchronous	Supplement	Inquiry-Based Learning (Guided Inquiry), Associative Brainstorming

	Exoplanets – Kepler 186f, Gliese 436b, Cancri 55e and Trappist 1e		Synchronous	Supplement	Inquiry-Based Learning (Guided Inquiry), Active Learning (Discussion)
3	Rocket Launch Facility	5	Synchronous	Motivation activity	Inquiry Based Approach
	Lunar Base LeGuin - Biodome		Synchronous	Motivation activity	Inquiry Based Approach
	Lunar Base LeGuin & Observation Training		Synchronous	Supplement	Science Process Skills/5Es

Table 1. Summary of teaching modes and strategies.

	Lunar Base LeGuin		Synchronous	Supplement	Science Process Skills/5Es
	Lunar Base LeGuin	4	Synchronous	Supplement	Science Process Skills/5Es
4	Earth Unaltered and What-If Earth with No Moon	5	Synchronous	Motivation activity	Concrete - Pictorial - Abstract (CPA) Approach
	Rocket Launch Facility	4	Synchronous	Supplement	Concrete - Pictorial - Abstract (CPA) Approach
5	Propositions	11	Synchronous	Performance task	Digital Learning
	Conditional and Equivalent Statements		Synchronous	Performance task and reflection activity	Digital Learning
6	Sun-Moon-Earth System: Solar Energy, Habitable Zone	7	Asynchronous	Motivation activity	Self-discovery
			Synchronous	Pre-lecture activity	Inquiry-based learning
	Sun-Moon-Earth System: Seasons		Asynchronous	Motivation activity	Self-discovery

			Synchronous	Pre-lecture activity	Inquiry-based learning
7	Ecosystem	8	Asynchronous	Pre-lecture and motivation activity	Digital Learning
			Synchronous	Lecture	Inquiry-Based Learning (Guided Inquiry) Active Learning (Discussion)
	Biodiversity and Evolution - Adaptation		Asynchronous	Pre-lecture and motivation activity	Digital Learning
			Synchronous	Lecture	Inquiry-Based Learning (Guided Inquiry) Active Learning (Discussion)

The project manager checked for the alignment of the learning design with the technical requirements of the WHIMC server and gave feedback on the general direction that the teachers envisioned for the module. The project manager also gave comments regarding feasibility, alignment of objectives to the flow of the lesson proper and/or project, or suggestions on alternative activities. The project manager then forwarded the reviewed first draft to the project lead for additional feedback or guidance. The project lead would provide comments related to the content, flow and suggestions on how to improve the module overall. The project manager would then forward the document with comments to the partner teacher. After receiving the reviewed document, the partner teacher revised the draft and resubmitted it to the project manager for review. Once the project manager completed the review, the revised module would then be forwarded to the project lead for review again.

Once the module draft seemed to comply with the learning design requirements sought for, the project team scheduled an internal dry run. The participants of the dry run were representatives of the project team, usually the project manager as the facilitator and the student assistants who acted as the teacher's students. The dry run usually ran for two hours: an hour for the module implementation, and the next hour for feedback-giving/processing. The teachers conducted the dry run as they would conduct a class. They went through the lesson and asked the participants questions. All other participants responded to the teacher's prompts. After the module dry run, the participants provided feedback about the session. They identified what they liked about the learning design and what they thought could be improved. After the dry run, the partner teacher revised and finalized the module. Figure 6 shows an excerpt of a final module.

4.4 Student Onboarding

To help teachers get their students ready for the WHIMC module implementation, the project team provided the teacher with the following documents/presentations for their reference:

- Summarized Research Protocol – This document contained the WHIMC project's overall objective, general data collection process, and data collection instruments.
- Minecraft Launcher Installation Guide – This document provides the instructions on how to install the Minecraft launcher, and a link to a basic tutorial video of how to play Minecraft.
- WHIMC Server Guide – This document contained step-by-step instructions on how to add the WHIMC server, and the information the students would need to input such as the server address. The project team suggested that the partner teacher only provide this when he or she already wanted them to access the WHIMC server for their asynchronous activity, or one (1) to two (2) days before the official synchronous session as designed in the module developed.

Three (3) weeks before the module implementation, the project manager gave the teacher the Minecraft account credentials to be assigned to each student who would be participating in their class. The teacher would then decide when he or she would distribute these credentials to the students. The PH team recommended that teachers send these credentials at least two (2) weeks before the module implementation date. The project team's technical support team was also on stand-by via the Viber messaging application for any concerns from the teachers (e.g., students unable to download the Minecraft launcher or students unable to sign in).

4.5 Implementation support

During the implementation of the module in the actual classes, only the teacher interacted with the students. The PH team did not interact with the students directly. However, members of the PH team, usually the student assistants, were available inside the Minecraft server for the duration of the asynchronous activities and synchronous class sessions to help troubleshoot student issues that may arise. Examples of these included getting stuck in a hole or inability to enter a portal. In these cases, the PH team would teleport students to the target destination so that they could continue with the game. The student assistants supporting the teacher would answer questions through the Viber messaging application or through a synchronous online meeting with the teacher.

4.6 Post-implementation Debriefing

About two weeks after each module implementation, the partner teacher was invited for an online debriefing session with the project lead, project manager, and the student assistant/s who acted as the teacher's technical support during the module implementation period. The project manager was the main facilitator for the debriefing sessions. The student assistant was present to take notes and to share his/her perspective.

The goal of the debriefing was to determine the following:

1. Whether the teachers regarded the module implementation to be successful or unsuccessful.
2. What factors contributed to the implementation's success.
3. What opportunities there are for improvement of the module design and implementation process.

Some teachers expressed feeling nervous and anxious prior to module implementation, worrying about their inexperience with Minecraft as a teaching tool and uncertainty about how well the students would learn from the experience. However, after module implementation, the majority of teachers reported that their implementations were successful both cognitively and affectively. Student responses to discussion questions were satisfactory to very satisfactory. Teachers were impressed that the students' answers to the questions had high levels of quality and depth. Teachers also said that students were enthusiastic, demonstrating a high level of appreciation for this computer-based interactive class activity. Students also showed a willingness to help when a classmate was encountering technical difficulties.

The teachers cited examples of factors that contributed to the module design and implementation success. Some factors related to the administrative and pedagogical support that the research team provided. For example, teachers said they were given enough time to familiarize themselves with the game, prior to crafting their modules. They appreciated that the research team provided them with tips about possible student pitfalls and roadblocks. The feedback sessions and the dry run also helped them refine their module content as well as the actual implementation process. Other factors were internal to the teacher himself or herself. For example, teachers said that prior experience with online teaching or with tools such as EdPuzzle bolstered their confidence. Prior experience using scientific inquiry as a teaching strategy also enabled them to craft a module that used WHIMC appropriately. Teachers' personal resources such as having two laptops at their disposal made technical implementation much easier.

Teachers also cited some opportunities for improvement. In terms of the module preparation, the first partner school who implemented said that the requirement for post-module assessment was not made clear to them. This should have been explained during the module design process so that they could have better prepared for an evaluative assessment. For the other partner schools, however, the need for an evaluative assessment in their modules was clearly communicated. During the actual WHIMC session with the students, it was relatively common for students to have problems with logging in, accessing the server, and navigating around WHIMC. These problems were resolved by the technical support team and by their classmates. One teacher had a particularly problematic implementation because the students were not able to set up their Minecraft accounts and complete the Minecraft launcher installation prior to the scheduled implementation day, so the implementation had to be rescheduled. These technical difficulties led some teachers to suggest that one session should be allotted for a "tech run" or student familiarization with the WHIMC environment before the actual implementation.

There were also opportunities to contribute to teacher professional development. While most teachers agreed that WHIMC was aligned with their curriculum, they also noted that WHIMC contained information that was unfamiliar to them. It would therefore be useful if the teacher did some reading on these topics prior to or during module design so that they can better refer to this content. Teachers with no prior experience of using games in their classes said that it would benefit their peers to observe a WHIMC session to enable fellow teachers to learn how to use the worlds in their classes.

5. Discussion and Conclusions

The goal of this paper was to contribute a description of teacher preparation activities for game-based learning. In doing so, it hoped to help fill an existing gap in the literature regarding the essential role that teachers and teacher preparation play in the integration of games in curriculum.

The technical, pedagogical, and content knowledge support that PH team provided enabled teachers to integrate a WHIMC module in their classes with some success. In terms of technical support, the PH team made the WHIMC server and Minecraft accounts available to the teachers and their students. We provided an onboarding process for the teachers in which they were familiarized with the WHIMC environment. For students, the onboarding process was limited to written guides and should be expanded to a guided hands-on session to ensure a smoother module implementation session.

To support teachers pedagogically, we familiarized them with the goals of the WHIMC project. More importantly, we reviewed teacher-designed modules at least once, conducted a dry run and provided detailed feedback immediately after the said run. These processes helped teachers refine their module designs and build confidence to implement the modules developed. The teachers identified one more method of pedagogical support that can assist in future implementations: peer observation. If fellow teachers were allowed to observe the module implementations, the exposure may teach them new methods of using ICTs, specifically games, in their classes.

Although most content knowledge sprung from the teachers themselves, the PH team's support was in ensuring alignment, to the extent possible, between curricular goals of the partner school and WHIMC activities. The PH team encouraged teachers to leverage on conversations with characters in the game, tasks the students had to perform within the game, or tools students had to use in order to complete the game missions.

From this experience of supporting teachers as they developed and implemented their WHIMC modules, the PH team derives four reflections:

First, teachers are enthusiastic about trying out new technologies, even if doing so is time consuming. The teachers who participated in this study were all teaching full-time. Furthermore, the study was conducted in the middle of the pandemic. This meant that their participation was another task added on to their already busy schedules. Still, they participated willingly and were able to deliver their assigned tasks.

Second, teachers need comprehensive and continuous support if they are to move beyond productivity tools to more innovative, inquiry-based, student-centered learning activities. The teachers who participated in this study were already quite proficient with ICT. Several of them had been certified and one had even won an award for ICT integration. However, they still expressed apprehension as the technology needed to mount something like game-based learning is usually less familiar than productivity tools or online polls. The technology platform therefore has to be established and debugged, after which, teachers need help learning it and students need help navigating it. The pedagogical approaches will also depart from traditional lecture-based instruction, so the activities have to be planned such that they are free enough to allow exploration but guided enough to achieve learning goals. Teachers need content support to ensure alignment and coupling between the technology and the curriculum.

Third, even when these supports are made available, there is no guarantee of success. Students will get lost. Timing of lessons will get derailed. Alignment or coupling with curriculum will be weak. The best that these support frameworks and structures can do is increase the probability of a successful module design and implementation.

Finally, there is the challenge of scaling up. The experience narrated in this paper was of a small group of teachers and a relatively small group of students. It exemplifies the reality of innovations of this kind: they are islands whose examples do not get diffused. For these innovations to make a difference to more learners, they have to be implemented systematically and at scale (Tondeur, Forkosh-Baruch, Prestridge, Albion, & Edirisinghe, 2016). This requires a sharing of experiences— something teachers are eager to do—and a scale up of TPACK support.

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Development of an App and Videos to Support the Fraction Learning Trajectory from Grades 1-7

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Abstract: Lack of procedural fluency in fractions impedes access to advanced mathematical courses and limits opportunities for entry into STEM-related fields. This paper describes the design and pedagogical basis of the *Moving Fractions* app and supplementary fraction videos for promoting fraction learning. *Moving Fractions* utilizes game-design factors to draw students through a trajectory of fraction learning from part-whole comparisons to a more robust understanding of the measurement concept of fractions. The supplementary video immerses students in a broad range of fraction representations. The app and video are intended to form a fraction learning package for distribution in Philippine schools. Future work involves the gathering of empirical data for validating the expected benefits associated with the application of mathematics education research in the app and video design.

Keywords: mathematical app, fraction, STEM, educational video

1. Introduction

Mathematics plays a fundamental role in STEM education. Students entering STEM-related fields are those who typically perform well in high school mathematics and have positive attitudes towards mathematics (Wang, 2013). Specifically, procedural fluency in fractions was found to improve access to advanced mathematical courses (Ngo, 2018). Students who do not learn fractions properly tend to perform poorly in subsequent mathematical courses (Booth & Newton, 2012), and may demonstrate limited mathematical competencies (Schneider et al., 2018). Unfortunately, many students and even pre-service teachers do not have a robust understanding of fractions (Bansilal & Ubah, 2020). Therefore, early interventions in fraction learning are important to increase opportunities for entry into STEM- related fields.

The design of games and game-based applications (apps) in classrooms has drawn the attention of mathematics education researchers for decades (Larkin, 2013). Games have been shown to increase students' engagement and motivation (Erhel & Jamet, 2013), and increase mathematics performance in various domains such as fractions (Ninaus et al., 2016). This paper discusses the *Moving Fractions* app for PC and Android that has been designed and developed to support the learning of fractions. The app is one of the mathematical resources that has been developed under an ongoing government-funded project (De Las Peñas et al., 2021), one of the goals of which is to strengthen further the mathematical competencies in foundational concepts necessary for more advanced learning. These include place value, number sense and fraction number sense. Aside from the app, mathematical videos were also created for students to help them visualize abstract ideas. In the past two years of the pandemic, these resources have been useful in support of the blended learning modality in schools called for by the Philippine Department of Education (DepEd). The resources for instance, can be used with minimal supervision, and are ideal for distance learning. An interested reader is invited to visit https://mathplusresources.wordpress.com/ for access to the mathematical resources.

2. Pedagogical Basis: Fraction Understanding

Learning fractions offers substantial challenges for students because traditional instruction does not present fractions in a precise and coherent way (Wu, 2010). Fractions are typically presented as part- whole comparisons (like pieces of pizza), leaving students with an impoverished understanding of fractions (Lamon, 2007). To learn fractions meaningfully, students must learn what fractions are, and how correct procedures can be logically derived from the definition (Wu, 2010). According to Wu (2010), the fraction $1/n$ is defined to be the point on the number line corresponding to dividing the unit segment into n equal parts, and taking the first division point to the right of 0; the fraction m/n is the mth multiple of the fraction $1/n$. Wu argued that a definition based on number lines is more superior than part-whole conceptions of fractions because all basic facts about fractions can be derived from the number line, but not from part-whole knowledge. Some educational systems also present alternative representations such as area and discrete models as a starting point before a number line model is introduced (Alajmi, 2012).

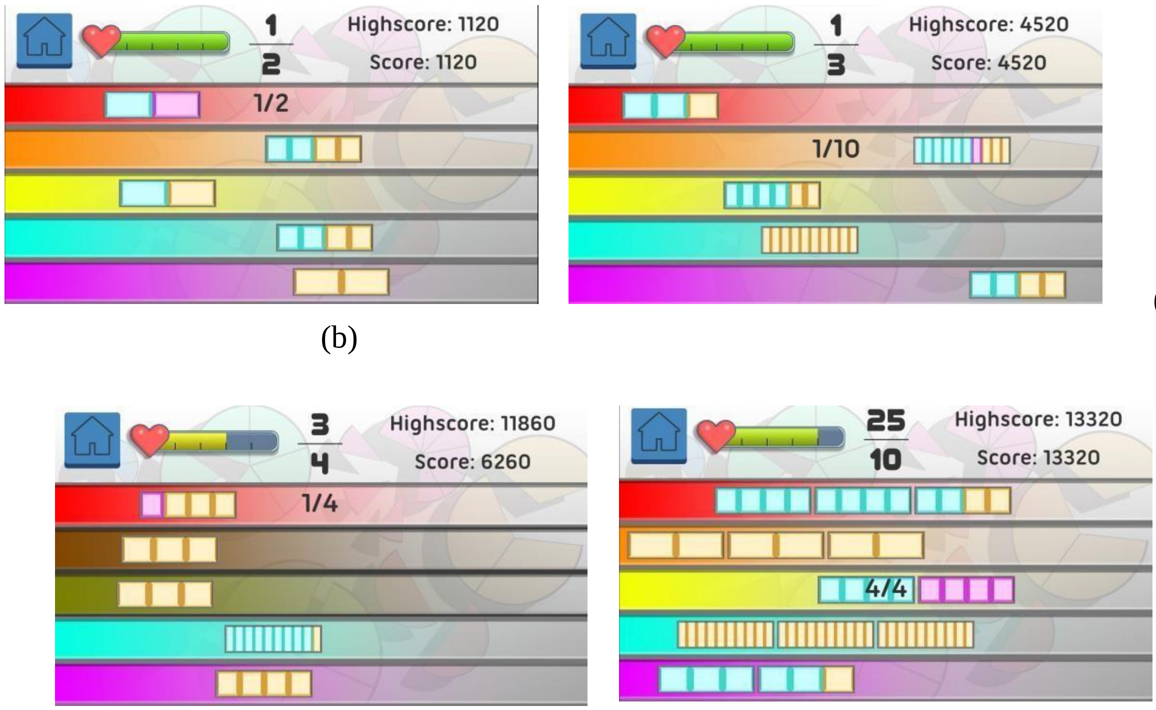
Instruction based on measurement concepts of fractions (i.e., thinking of m/n as m measures of $1/n$; see Kieren, 1980) offers the strongest conceptions of fractions, allowing students to apply their knowledge to new problems and form alternative conceptions of fractions that were not taught (Lamon, 2007). The measurement construct of fractions was further delineated by Wilkins and Norton (2018). They summarized studies involving more than 300 students to propose a hierarchy of fraction schemes, beginning with part-whole to measurement concepts of fractions: (a) part-whole scheme (PWS), (b) measurement scheme for unit fractions (MSUF), (c) measurement scheme for proper fractions (MSPF), and (d) generalized measurement scheme for fractions (GMSF). The PWS and MSUF are loosely inverses of each other– partitioning a whole into n parts versus determining the fractional size of a unit fraction by iterating the unit fraction to produce the whole. The action associated with MSUF involves producing a whole from a proper fraction, and the action associated with GMSF involves producing a whole from any fraction (including improper fractions). The results collectively show that these schemes developed sequentially (i.e., the development of PWS preceded the development of MSUF, and so on).

These fraction schemes are aligned with the Philippine DepEd Most Essential Learning Competencies (MELCS) (DepEd, 2020), where students learn fractions in progression: from ½ and ¼ (Grade 1), followed by unit fractions and proper fractions (Grade 2), improper fractions (Grade 3), equivalent fractions and addition and subtraction of fractions (Grade 4). An app and supplementary videos based on this hierarchy are expected to develop a more robust understanding of fractions, compared to learning materials concentrating on part-whole comparisons alone (Lamon, 2007; Wilkins & Norton, 2018).

3. The *Moving Fractions* App

3.1 App Description

In *Moving Fractions*, a learner may choose to play the following levels: ½ and ¼ fractions (Figure 1(a)), unit fractions (Figure 1(b)), proper fractions (Figure 1(c)), improper fractions (Figure 1(d)) and proper, improper, and mixed fractions combined. A fraction is given on the top of the screen, such as 1/3 in Figure 1(b), while partitioned rectangles or fraction bars continuously move to the right. The learner must click on any row where the given fraction can be represented. In Figure 1(b), the fraction 1/3 can be represented by the fraction bars in the first row (with a bar divided into three) or in the third row (with a bar divided into six). If the learner clicks on any of these rows, then the fraction bar on that row would slow down its movement, and the given fraction would be shaded blue. Returning to the example in Figure 1(b), if the learner selects the first row, then the fraction bar would have an additional 1/3 shaded blue, so that the entire rectangle would be shaded blue. If this happens (i.e., a fraction bar is completely shaded), then the bar moves back to the left end of the screen. The goal is to delay the forward motion of the fraction bars and prevent them from reaching the right end of the screen by correctly selecting the fraction bars that can represent the given fraction. If a fraction bar reaches the right end of the screen, then that row would be darkened (such as the second and third rows in Figure 1(c)). Each time a row is darkened, the number of "lives" indicated by the scrollbar with a heart on the upper left of the screen decreases by one. The game ends when fraction bars in the five rows reach the right end of the screen. *Moving Fractions* is available as an Android app that can run in Android- powered smartphones or tablets or as a computer app that can be used in Windows personal computers or laptops.

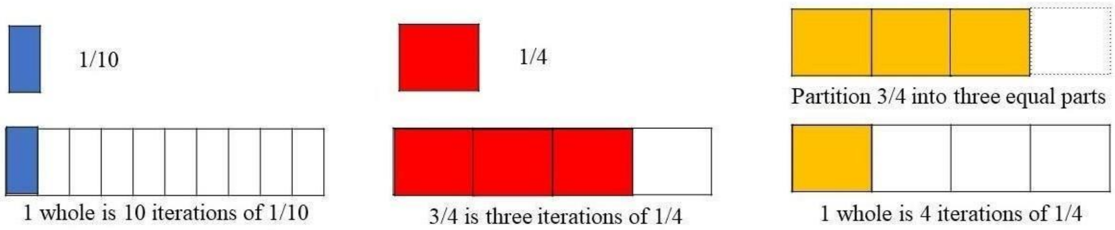


(b) (a)

(c) (d)

Figure 1. Screenshots showing four of the five levels in *Moving Fractions*.

In playing the different levels in *Moving Fractions*, learners understand fractions by developing the four schemes proposed by Wilkins and Norton (2018). When learners play the 1/2 and 1/4 level (Figure 1(a)) and the unit fractions level (Figure 1(b)), they see the relative size of a unit fraction to a whole and realize that *n* iterations of 1/*n* produce 1 whole. For example, 10 iterations of 1/10 produce 1 whole, thus developing the MSUF (Figure 2(a)). In playing the proper fractions level (Figure 1(c)), learners see the relative size of a proper fraction *m/n* to a whole and to the unit fraction 1/*n*, thus developing PWS and MSPF (Figures 2(b) and 2(c)). Learners operating with MSPF realize that a whole can be reproduced by partitioning 3/4 into three equal parts and iterating one of those 1/4 parts four times to produce a whole (Figure 2(c)). Similarly, when playing the improper fractions level (Figure 1(d)) learners see the relative size of an improper fraction *m/n* to a whole and to the unit fraction 1/*n*, hence developing GMSF.



(a) (b) (c)

Figure 2. Three of the four fraction schemes are (a) MSUF, (b) PWS and (c) MSPF.

The learning progression from PWS to GMSF was used in the development of other apps, such as in the CandyFactory app (Aslan, Norton, & Balci, 2012). However, *Moving Fractions* has distinct game mechanics that differentiate it from the CandyFactory app. In the CandyFactory app, children learn partitioning and iterating within the context of a company that needs to fill orders of candy that meet certain requirements in terms of its size. *Moving Fractions* demonstrates the fraction schemes more indirectly and through a faster-paced game-like approach. The next section discusses the game- design features of *Moving Fractions* in more detail.

3.2 Game-design Factors

Aligned with the objectives of the ongoing project (De Las Peñas et al., 2021), the authors have been developing mathematical resources that are based on sound pedagogical research and that can prove beneficial even for students who are in distance learning modes. One way this has been achieved is by developing mathematical apps such as *Moving Fractions*. By integrating game-based elements in *Moving Fractions*, it is aimed for learners to be more engaged and interested with studying fractions that may lead to their development of analytical thinking, strategizing, and problem-solving that are important skills in STEM education (Vahidy, 2019). Furthermore, it is envisioned that *Moving Fractions* can be a mathematical resource that is “not only aligned with the curriculum but [is] also creative, fun and provide[s] opportunities to learn” (Miller, 2018, p. 9).

The development of the *Moving Fractions* app as an educational game is also motivated by previous studies where classroom teaching activities have been transformed into game-based versions. Hu and Shang (2018), for example, designed gamified teaching activities using mobile applications.
More recently, Verzosa et al. (2021) developed a game-based version (i.e., an app called *Catch the Carrot*) of traditional number estimation activities for grade school students.

Moving Fractions has been developed in consideration of the 11 interrelated game-design factors in the Game-based Learning (GBL) Design Model of Shi & Shih (2015). These game-design factors are game goal, game mechanism, game fantasy, game value, interaction, freedom, narrative, sensation, challenges, sociality, and mystery.

As previously mentioned, the *game goal* of *Moving Fractions* is, at each turn, to identify the occurrence of a given fraction in five rows each containing one or more partitioned rectangles. The game goal facilitates the learning of fractions through the fraction schemes of Wilkins and Norton (2018). Figure 3 following the layout used by Shi & Shih for the GBL Design Model (Shi & Shih, 2015), further presents the game-design factors as they relate to *Moving Fractions*.

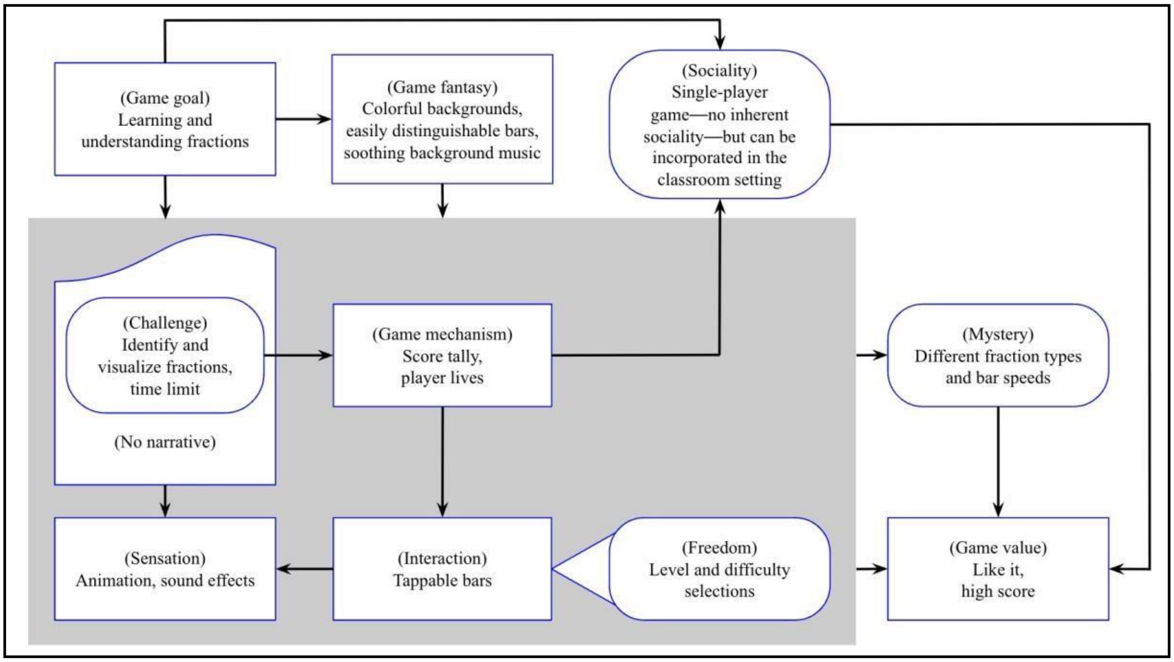


Figure 3. The GBL Design Model for *Moving Fractions*.

The *game mechanism* involves an arcade-type format in which learners must score as much as they can with a limited number of lives. Learners must keep track of the horizontally moving rectangles and quickly tap (*interaction*) correct rows—this increases the game's excitement and replayability.
Moreover, to allow learners to adjust to their current ability levels, the game provides the learners the *freedom* to select the level and difficulty they want to play.

As *Moving Fractions* is intended to be a straightforward replayable game with simple objectives, it has been decided not to integrate *narrative* and *sociability* elements into the game. Instead, the focus is to build the *game fantasy* through colorful backgrounds and soothing music. The animations and sound effects also enhance *sensation* within the game, making it more immersive and exciting for learners. It must be noted, however, that while *sociability* is not built inherently into the game, it may be incorporated when the game is played by multiple learners.

The *game value* depends largely on whether the learner likes the game and is motivated to achieve high scores. This is enhanced by the game's *challenges* that correspond to the increasing difficulty as one progresses through topics on fractions and applying this knowledge to play the game. The availability of multiple levels also adds to the game's *mystery* as learners can become curious about the new elements that can appear in the next levels.

4. Supplementary Fraction Videos

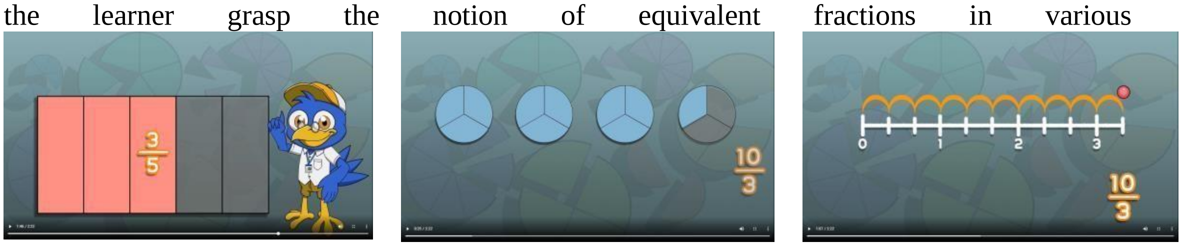
A supplementary tool developed to help promote a deep conceptual understanding of fractions is a series of videos demonstrating various ways that fractions may be represented. These videos are different from existing videos that are available online. First, these are short yet contain three models or representations: the area model, set model and number line model. The use of multiple representations provides a powerful means by which learners can visualize the idea of fractions. Second, the videos also present some questions at the end, to engage the viewers in the thinking process. Third, the text is minimized to lessen the viewers' cognitive demand.

The first video introduces the learner to the concept of ½ and ¼. A representation of these fractions using the area model shows objects (such as a rectangle, circle, triangle, heart, fruit) breaking into two or four equal parts (Figure 4(a)). This helps a learner grasp the idea of these fractions in terms of a part-whole scheme (Wilkins & Norton, 2018). The set model representations of ½ and ¼ shows a set of discrete objects being partitioned into two groups with the same number of objects is shown (Figure 4(b)). Here the learner relates ½ to the notion of segregating one set of objects into two smaller groups with an equal number of elements. Following the definition given above (Wu, 2010), a third representation of the unit fractions is through a number line model. For instance, the portion of the number line from 0 to 1 is shown as being split by a midpoint mark and the fraction ½ is visualized by the animation of a jump from 0 to the midpoint mark (Figure 4(c)). A similar number line model is used to depict ¼.

(a) (b) (c)

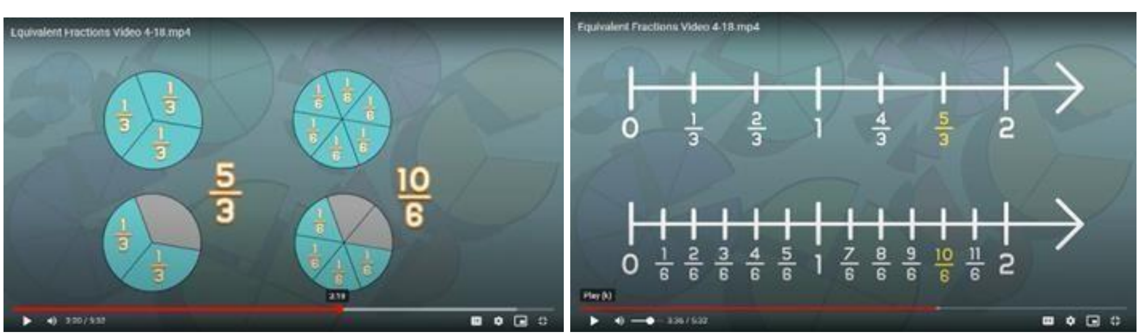
Figure 4. Representations of ½ using (a) area model; (b) set model; and (c) number line model.

These multiple representations of fractions are reinforced in succeeding videos that depict proper and improper fractions, equivalent fractions, addition, and subtraction of fractions (Figure 5). The concepts demonstrated in the videos build on each other. A video on *Equivalent Fractions* shows the equivalence of the (improper) fractions 5/3 and 10/6 using the area model (Figure 5(d)) and the number line model (Figure 5(e)). The repetitive use of various representations to illustrate other fractions which are equivalent helps the learner grasp the notion of equivalent fractions in various ways.



(a)

(b) (c)



(d)

(e)

Figure 5. (a) Proper fraction ⅗ (area model), (b) improper fraction 10/3 (area model), (c) improper fraction 10/3 (number line model), (d) equivalent fractions 5/3 and 10/3 (area model), and (e) equivalent fractions 5/3 and 10/3 (number line model).

Another video on *Addition and Subtraction* of similar fractions animates the idea of putting together or removing several copies of a unit. For instance, the operation 5/2 + 7/2 is depicted in Figure 6(a) which shows five and six copies of ½ of a papaya, respectively. The sum is shown by putting together the unit pieces to make 12/2 or 6 papayas (Figure 6(b)). The notion of subtraction is similarly made more accessible by animating the removal of unit pieces from a whole (Figure 6(c)).

(a) (b) (c)

Figure 6. Illustrations of (a) 5/2 + 7/2, (b) sum of 5/2+7/2, and (c) 14/5 – 8/5.

5. Integration and Use of *Moving Fractions*

This section describes how Moving Fractions can be utilized as a pedagogical tool based on the RAT (Replacement, Amplification, Transformation) framework (Hughes, Thomas, & Scharber, 2006). The choice of replacement, amplification, transformation or combination of any of this may depend on the classroom context, nature of students and curriculum content and goals.

Based on this framework, the Moving Fractions app can serve as a replacement for the traditional method of teaching fraction understanding without changing content and learning goals in relation to fractions remain the same. For example, the fraction strips or circular regions which are often used by teachers to illustrate and represent fractions are now replaced by the moving fraction bars in the app. The task of representing fractions (unit, proper, improper) remains the same but the static method of presenting them is now changed to the colorful and dynamic representations of fractions. Such representations can be used by the teacher to discuss relationships between different types of fractions.

Moreover, integration of the app can go beyond the replacement category. The framework suggests that technology can amplify learning. This happens when concepts are presented more clearly and efficiently. The app provides a more precise and accurate representation of fractions than can be done without technology. For example, the fraction ⅕ is difficult to illustrate by hand. But with the app, this fraction is presented accurately. The design of the app can also help students understand different representations of fractions (e.g., ½ is 2/4 or ⅓ is 2/6). Teachers can maximize this feature of the app so that misconceptions about fractions can be addressed.

Finally, technology can involve transformation of instructional methods, learning process, and/or the content. The app may spur a transformation in teachers' instructional practices from being teacher-centric or teacher-controlled to student-centered. By playing with the app, the learning process is transformed as the feedback mechanism heightens student engagement and facilitates opportunities for discovery. The app can be used as a tool for collaborative activity where students can communicate their thinking and experiences in playing the app. Such activity also helps students to work with others and create a positive learning environment. Learning need not come solely from the teacher's input but from the app itself. Further, the game-like environment of the app allows students to create efficient strategies in order to prolong their life in the game.

6. Conclusion and Future Direction

Competency in fractions is identified as an essential skill for entry into STEM-related fields. The *Moving Fractions* app and the supplementary fraction videos were designed to develop learners' knowledge of fractions. The app utilizes game-design principles to concretize the learning trajectory of fraction learning, from part-whole comparisons to a more robust understanding of the measurement concept of fractions.

Meanwhile, the fraction videos immerse learners in a range of fraction representations that can extend their initial part-whole understanding of the fraction concepts. The next step is to package the app and videos and gather empirical data on how the fraction learning package can promote fraction understanding.

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Implementing STEM Integrated Inquiry-Based Cooperative Learning of Smart Factory System

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Abstract: Nowadays, smart factory system learning has been increasingly mentioned in vocational education, considered guidelines to enhance students' understanding of a manufacturing situation in a realistic industry. However, it is challenging to teach the students to understand and practice. Thus, it should be cultivated in the curriculum of Technical Vocational and Training (TVET). This paper describes the STEM integrated inquiry-based cooperative learning approach of the smart factory system course. Forty first-year diploma students major in mechatronics and robotics engineering at TVET College in east Thailand participated in this study. This research finding shows the student's learning performance increasing and positive attitudes toward collaborative exploration learning management under the STEM study guidelines on a smart factory system course for TVET students.

Keywords: Inquiry based learning, smart manufactory, cooperative learning

1. Background and Motivation

Currently, the revolution of a new form of the industrial revolution is the form of digital networks (Digital networks), which are associated with intelligent operating systems in industrial plants, including design, development, and manufacturing, to installation and maintenance (Elvis, 2015) that enter the fourth industrial revolution or industry 4.0.

The technicians or workers are a critical force that will dramatically change the pattern of the industry. Especially the development of this group of craftsmen is significant, which must come from knowledge, experience, and technology. The number of workers in Thailand in the field of professional work with skills that meet the needs of the industry is only 30 million people out of a total workforce of more than 8-6 million people across the country or accounting for only about 15 percent to increase the workforce with such skills to reach the level of 40-45%. It is necessary to work together to accelerate the creation of 12-15 million professional workers into the system.

Therefore, Technical Vocational and Training (TVET) should have a system that aims to develop to meet the needs of the enterprise. Conducting practical training in laboratories with new technologies and collaborating with colleagues in the same line of work also increases the ability to engage in highly competitive careers. The curriculum of the vocational institutions must be improved to keep up with the rapidly changing industry conditions in the past few years. In addition, vocational graduates from industry 4.0 adaptation programs must have specializations such as software data analysis, cyber security, android application, and mechatronics discipline (Roll & Ifenthaler, 2021).

The 5E learning is a process that influences students' increased learning motivation and understanding of the concepts and participation in collective surveys and discussions. It also changes the learning environment, so students enjoy learning together (Daşdemir, 2016; Taengkasem et al.,2020; Chookaew & Panjaburee, 2022). Besides, it enables students to participate in practical learning through social skills that facilitate work; they can achieve better results when working together and understanding in teams and they can create a new body of knowledge by participating in carrying out activities.

Ali (2014) suggested that science educators encourage teachers to change teaching methods from teacher-centered teaching and focusing on the lectures in the textbooks to change to a quest-based method as 1) Emphasis on learners' interest in science, 2) Gives students opportunities to use practical techniques, 3) Allow learners to solve problems using logic and evidence, 4) Encourage students tostudy for more information to be able to find a way to explain more complex information, and 5) Paying attention to writing an explanation from the scientific evidence. This approach points to a classroom environment in which the community is seen working on a quest: science knowledge and the same proof-of-scientist process. It shows the importance in the future for driving the industrial system to keep up with new technologies (Zhang & Ming, 2021; Chookaew et al., 2021). The management can increase productivity for better efficiency, including personnel development skills following enterprises' needs in the industrial sector to keep up with the rapidly changing industry and support the industry 4.0 approach

Thus, TVET students should gain knowledge and expertise in industrial factory systems using information technology so that they will experience and be able to develop ideas, innovations, and professional skills. Mainly the high vocational certificate student level because learners at this level have skills and abilities. They have learned the concept of Introduction to tools and equipment, including basic knowledge related to industrial systems. In addition, it is the age when it is necessary to cultivate practice guidelines and attitudes to work with others to achieve the ability to perform the primary duties of the supervisor of entrepreneurship and be an innovator. This research aims to develop students' performance to learn industrial factory systems to meet the needs of the workplace and modern technology and to create an attitude to work together. Two research questions guided this study:

RQ: How does the STEM integrated inquiry-based cooperative learning to promote students' performance?

RQ2: How does students' attitude participating in the STEM integrated inquiry-based cooperative learning?

2. Smart Factory System Learning

The researcher analyzes the smart factory system's behavioral objectives, knowledge, and skills that students must acquire and considers the learning process. They will receive both terms of knowledge understanding of the content and applying the skills learned to be tested for assessing learners' skills from studying in each unit. The student must learn conditionally from units 1-3. They can practice after completing the study according to the planned process and continue until the end of the lesson, as shown in Table 1.

According to the planning activities and lesson plan that focuses on collaborative learning processes using STEM education to integrate content and knowledge for learners, there are steps of activities for cooperative inquiry learning, as shown in Figure 1.

Table 1. *The behavioral learning objectives*

Unit	Topic	Behavioral learning objectives
1	- TCP/IP settings - Stack Magazine Station I/O map settings. - Conveyor Station I/O map settings.	1. Set the IP of the PLC to be able to connect to the computer. 2. Set the input and output of the Meclab training set in the I/O map correctly. 3. Define variables used for inputs and outputs of Meclab training sets used to connect to PLCs.

2	- Programming to control the operation of the Stack Station - Programming to control the operation of the Conveyor station.	4. Write a program to control the operation of the Stack Magazine Station. 5. Write a program to control the operation of the Conveyor Station.
3	- Creating a monitor to simulate the operation of the Stack Magazine Station. - Creating a monitor to simulate the operation of the Conveyor station.	6. Create a model on the monitor for controlling the Meclab operation. 7. Design a monitor for controlling Stack Magazine Station operation. 8. Design a monitor for displaying the performance of the Stack Magazine Station. 9. Design a monitor for controlling the operation of the Conveyor Station 10. Design a monitor for displaying the performance of the Conveyor Station.

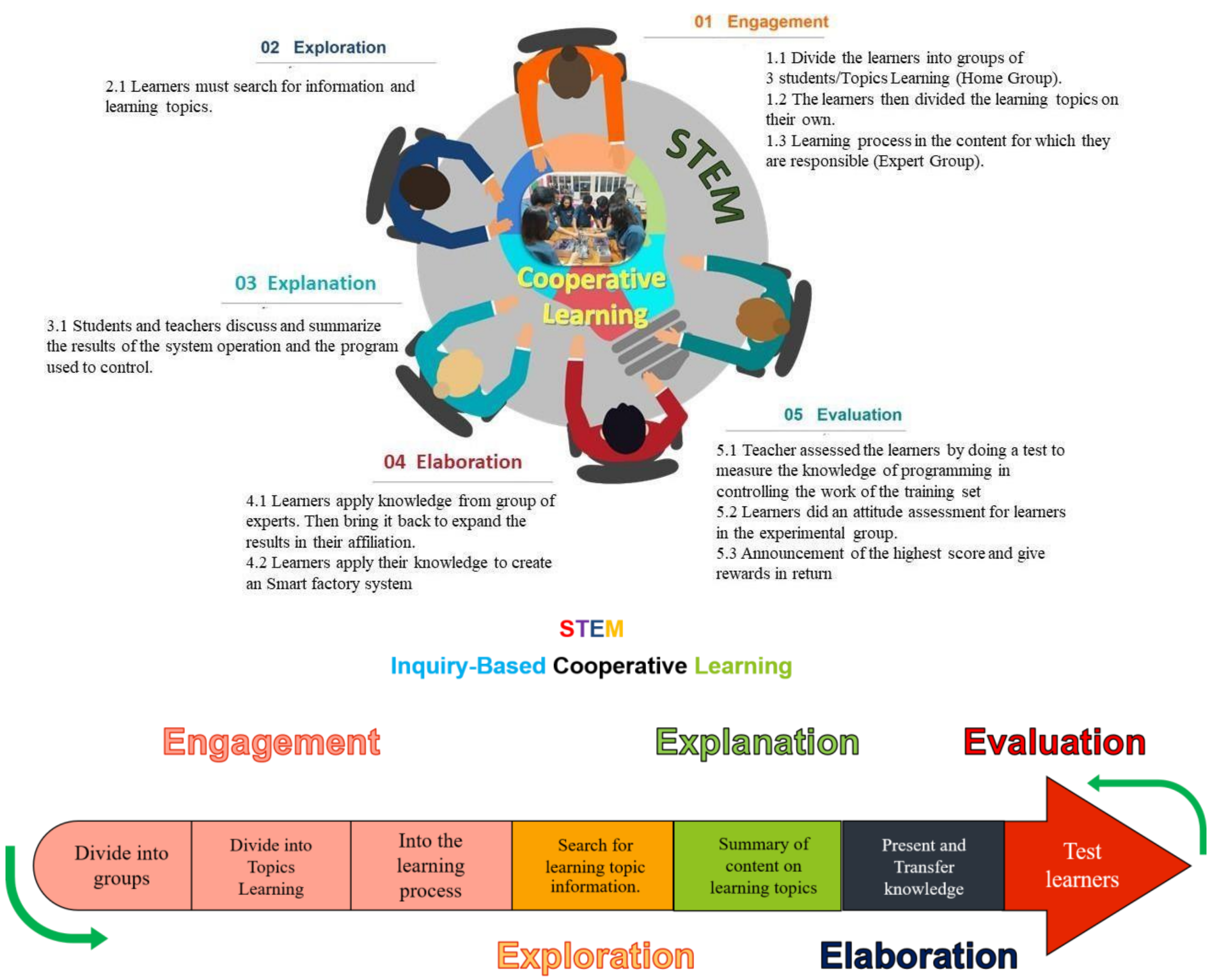

Figure 1. An overall structure of STEM Inquiry-Based Cooperative Learning.

In this study, we developed the training kit to simulate industrial factory systems consisting of workpiece distribution Pneumatics, a cylinder to push the workpiece, conveying to uses a DC electric motor system, and sorting workpieces to use an electric valve in the separation. After that, we combine two systems to create the initial simulation size industrial system. All device used to control the system's operation is the Programmable logic controller (PLC) (Omron: NX-series NX1P2 CPU Unit hardware), as shown in Figure 2.

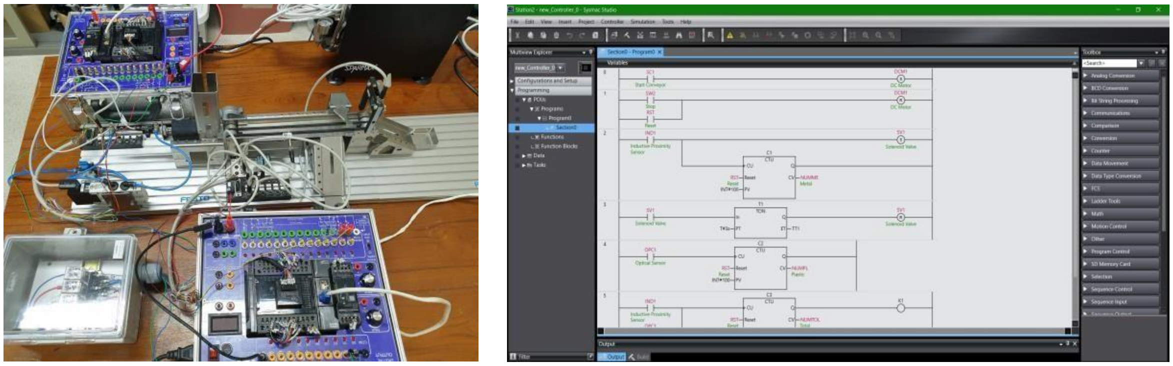

Figure 2. Smart factory system training kit (left) and PLC program in Sysmac Studio (right).

3. Methodology

3.1 Participants

This study was conducted at Thai-Austrian Technical Collage in east Thailand. Forty first-year diploma students majoring in mechatronics engineering and robotics at TVET College in east Thailand participated in this study. They registered for factory automation courses with a grade of 2.00 or higher. They were divided into 20 students in experimental and 20 students in control groups. The experiment group will use the cooperative inquiry learning teaching method, focusing on doing activities together among students.

Then, the students took the test to measure the practice skills assigned by the teacher. Afterward, they took the checklist assessment criteria for assessing the students' attitudes towards learning activities. In comparison, the control group will use traditional lecture-based learning. Then, the students took the test to measure the practice skills assigned by the teacher.

3.2 Learning Activities

The implementation of learning activities occurred during the three weeks in factory automation courses. The students in the experimental group will be divided into groups (each group of 3 students). Then, the instructor described the introduction to activity in the classroom and motivated related to the importance of industrial plant systems in the past from 1.0 to today's Industry 4.0. After that, the teacher explains the essential content and methods of operation of all learning units. All students participate in the learning activities and assignments. One of the students within the group appoints a representative to monitor all learning units within their group. The teacher uploads the content files that the students will have to study on their own through the students' Google Classroom. Then the representative students in each group disperse into their groups in each assigned unit.

The students have self-study with experiments following the operating methods of each unit. When a representative student completes the learning task, they will return to their original group to bring information that each person has studied in all learning units to transfer knowledge to members of their groups. Everyone in the group will receive complete details on all learning units through the transmission of information from members. Then, the students took the performance skill test (10item), as shown in Figure 3.

Figure 3. Students' learning activities.

4. Results

4.1 The Results of Students' Performance

The results of the self-assessment comparison before and after learning activity were in this study. The comparison results were shown in Table 2 and Table 3.

Table 2. *Results of pre-test comparison.*

Results of Pre-Test					
Group	n	X	S.D.	*t*	*sig*
Experimental group	20	7.05	4.22	-0.152	.88
Control group	20	7.30	6.04		

$p > 0.05$

Table 2 found that in the pre-study self-assessment of the students in the experimental group. The mean was 7.05 (S.D. =4.22), and in the control group, the mean was 7.30 (S.D. =6.04). The t-test results were not statistically different at 0.05; prior knowledge was no different.

Table 3. *Results of post-test comparison.*

Results of Post-Test					
Group	n	X	S.D.	*t*	*sig*
Experimental group	20	17.55	2.74	2.412	.02*
Control group	20	14.90	4.08		

* $p < 0.05$

Table 3, it was found that the self-assessment results after studying in the experimental group, the mean was 17.55 (S.D.= 2.74), and in the control group the mean was 14.90 (S.D.=4.08). The t-test results were significantly different at the 0.05.

The student's performance skills checklist of the smart factory system concept was used to evaluate students in both two groups, including ten items with a total score of 50. The assessment results were obtained from teachers as assessors. The results of the assessment of practical skills between the two groups of students are shown in Table 4.

Table 4. *The results of the student's performance skills.*

Results of Post-Test					
Group	n	X	S.D.	*t*	*sig*
Experimental group	20	41.08	11.22		
Control group	20	23.73	14.27	4.273	.00**

** $p < 0.01$

Table 4 shows that the mean of the learners in the experimental group was 41.08 (S.D.= 11.22), and the control group was 23.73 (S.D.= 14.27). The mean of the experimental group was higher than the control group. There was a statistically significant difference at 0.01.

4.2 The Results of Students' Attitude

The attitude assessment items divide into four dimensions are 1. Active participation within the group, 2. Interaction within the group, 3. The importance of members within the group, and 4. Skills and knowledge of working together in a group. We found that the assessment results of the students' attitudes by finding the average of the assessments were 4.32 (S.D.= 0.22). It can be considered that the student's positive attitude toward this approach is at a good level. In addition, the results from interviewing TVET students toward the STEM integrated inquiry-based cooperative learning are summarized in Table 5.

Table 5. *The Students' Attitude Interview*

Interview items	Students' Attitude Summary
When students participate in inquiry-based cooperative learning activity, how do students feel?	The students feel satisfaction when learning with friends within their group. They were an exchange of knowledge to complete the assigned tasks by doing group karmic activities. They can cooperate with the enthusiasm of the group members and mutual assistance so they can go through together.
When students work in a group, how do you communicate within the group?	The students want to communicate correctly, but some members may not have enough prior knowledge causing the misconception to be transmitted to other group members, especially difficult content that the student cannot understand.
When students work in a group, what are the student expectations?	The students expect to write programs following specified conditions. They want to gain more knowledge of PLC connection to the Internet of Things platform and use SCADA as an automated control system.

5. Conclusions

In the smart factory system course, it is sometimes difficult for students to understand the principles of writing programs following specified conditions with a PLC connected to the Internet of Things platform, especially when it is necessary to use SCADA as an automated control system. This paper describes the STEM Inquiry-based cooperative learning model of the smart factory system course. Forty first-year diploma students major in mechatronics engineering at TVET College in east Thailand participated in this study. The research found that the student's learning performance increasing and positive attitudes toward collaborative exploration learning management under the STEM study guidelines on a smart factory system course for TVET students.

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Learning Factory: A Proposed Framework for Engineering Learning Ecology by Automated Manufacturing System Kits

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Abstract: In the engineering education program, how to help engineering students fully understand the concept and practical procedure in industry, especially, mechatronic engineering students are encouraged to learn many concepts related to industrial, especially the challenges of Industry 4.0 technology. However, the industrial process is complex and lacks learning material covering the industrial manufacturing context, causing engineering students with no experience and knowledge of automated manufacturing technology. It is necessary to educate the next generation of student engineering, but the learning tools needed for education are often expensive, and lack of funding to buy learning material. Most importantly, technology changes and evolves rapidly. This study offers the development of an automated manufacturing system learning kit that can be used to teach engineering education. It consists of three stations: loading, assembly, and warehouse packing. In addition, the learning factory ecosystem presented in this study aims at a much broader use of novel learning methods to introduce mechatronics engineering students to understand the new digital manufacturing process. The study results inspire instructors and educational institutions to prepare engineering students with the knowledge and practical skills based on the learning factory ecosystem.

Keywords: Learning outcome, engineering education, learning kit

1. Background and Motivation

Nowadays, many countries demand multidisciplinary engineering and flexible workers capable of using new technology and solving relevant problems in the industry. Thus, mechatronics engineering is popular because it integrates mechanical, electronic, and electrical engineering systems and combines robotics, computer science, control systems, and product engineering.

In the development of the engineering education program, how to help engineering students fully understand the concept and practical procedure in the industry, especially mechatronic engineering students are encouraged to learn many concepts related to industrial, especially the challenges of Industry 4.0 technology. Therefore, they should receive methods to apply experiential learning concepts, which encourage creativity to provide solutions to real-world focus on competency-based education with learning experiences (Félix-Herrán, 2019)

Learning factories have become interested and expanded worldwide, especially in Thailand; it is popular to integrate teaching and to learn for engineering education. A learning factory is a learning environment that matches an industrial production setting to simulate production processes realistically while enabling practical training in many topics and professional levels through technologies and functions inside the learning factory based on current industry standards (Scheid, 2018). Learning factories appear as complex learning environments that allow the development of high-quality and autonomous competencies connected to training, education, and research (Baena et al., 2017). It includes implementing several technologies in the industry 4.0 environment driven by existing technological developments and the ability to process large amounts of data (Centea, Singh, & Elbestawi, 2019).

Many studies propose the learning material for utilization in the learning process. For example, Mourtzis et al. (2020) offered a highly automated and flexible manufacturing cell to enhance skills, competencies, and hands-on experience for a new generation of engineers. Berman et al. (2021) offered low-cost, portable air conditioning teaching and learning kits to improve students' understanding of vocational education. Mohammad et al. (2021) proposed a smart factory reference model as a guide to upgrading an existing production system towards the vision of Industry 4.0 using readily available components. It is a modular production system connected to a server accessible locally or through the internet with the application software to create the user interface.

The scope of this study effort is descriptive how to design and develop the low-cost learning material for mechatronics engineering students. An automated manufacturing system learning kit consists of three stations: loading, assembly, and warehouse packing.

2. Conceptual Framework

Learning outcome

The context of an educational institution of higher education focuses on developing student learning outcomes throughout the curriculum. The learning outcome is the goal of students learning and helps direct the instructional structure and determine how students will be after the teaching and learning process (Wongwatkit et al., 2018). This study proposed the automated manufacturing system learning kits to promote mechatronics engineering students based on the learning factory ecosystem. The automated manufacturing system concepts for mechatronics engineering students should be learned based on learning outcomes as follow the table below:

Table 1. *Program Learning Outcome*

Course concepts	Leaning outcomes
1. Manufacturing process component	Understand the manufacturing process.
2. Programmable logic controller (PLC)	Use PLC to control hardware.
3. Ladder programming	Write Ladder logic programming with PLC.
4. Pneumatic cylinders	Write programming to control pneumatic cylinders.
5. Photoelectric sensor	Apply a photoelectric sensor to detect an object.
6. Vision inspection systems	Apply a vision inspection system to track an object.
7. Robot control	Write programming to control Robot
8. Vacuum grippers control	Use Vacuum grippers to pick and plate the workpiece.
9. Dashboard	Display information on the dashboard.

3. Development of an Automated Manufacturing System Kit

In general, using the existing commercial products available in the market is expensive in a teaching and learning factory for engineering education. This study is based on a low-cost concept using a simple design and affordable materials and components to simulate the industry situation, allowing the students to apply their theoretical knowledge in practice. This learning kit's development consists of three aluminum profile stations. Each station includes sensors (machine vision), conveyors, a SCARA robot, Articulated robot. Overall stations were controlled with a programmable logic controller (PLC) to connect hardware devices and online services through Sysmac Studio Software to support ladder, structured text, and function block programming. Furthermore, Node-RED was used to show the dashboard performed data monitoring graphically. The design basis of the automated manufacturing kit consists of three stations, as seen in Figure. 1 and Figure. 2.

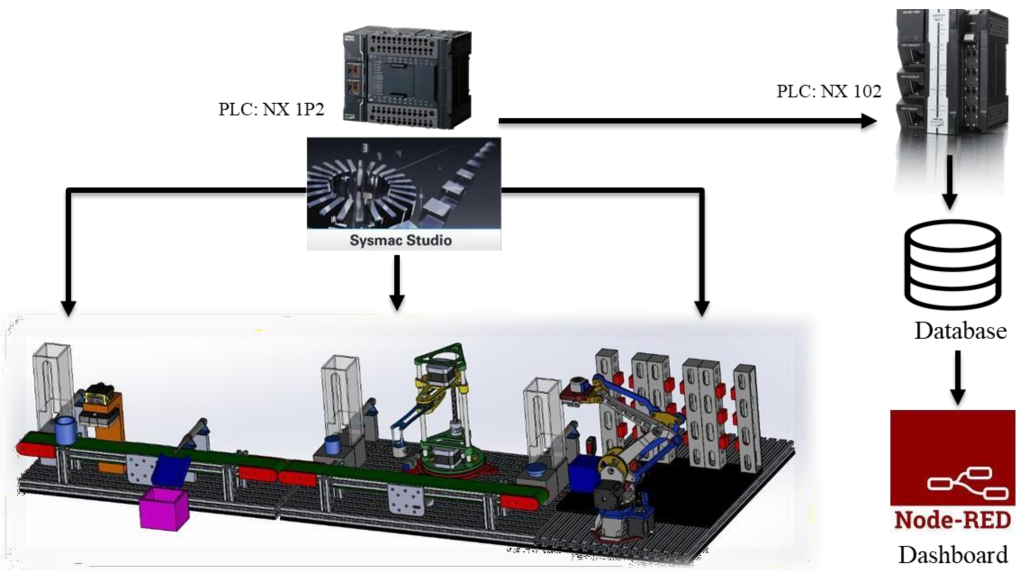

Figure 1. Design of an automated Manufacturing system kit.

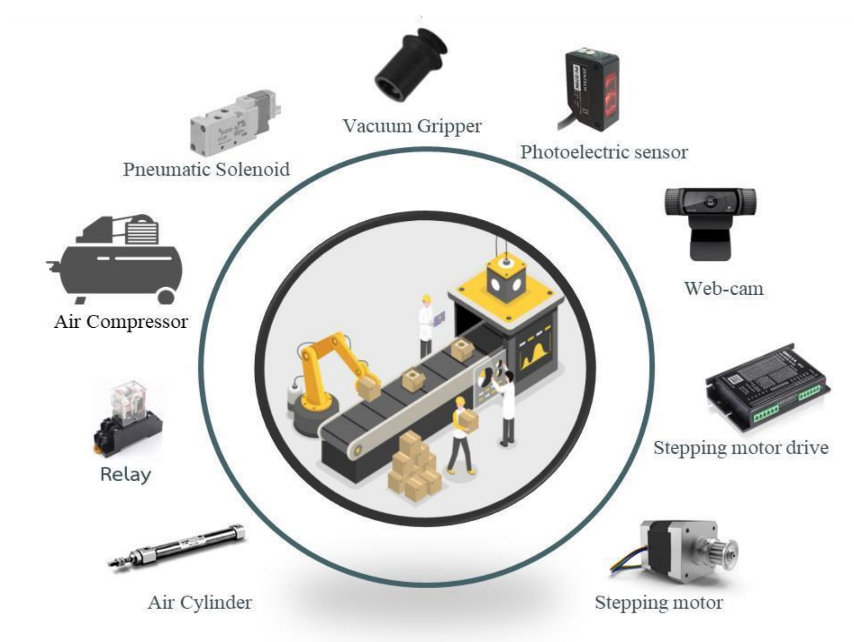

Figure 2. Basic material to developing learning kit.

3.1 Loading Stations

The loading station is a prototype for controlling the loading station of a factory automation system. It serves to load workpieces into the conveyors run and transport workpiece carriers with machine vision technology. It offers reliability and fasts detected based on machine vision that can help achieve real-time data analysis in a manufacturing environment. It can be implemented in any industry to perform real-time monitoring of workpieces. A conveyor for the workpiece carrier fed to the next station with programmable logic controller (PLC) order and notifying defects, sorting workpieces based on their physical parameters, and analyzing process abnormalities can be achieved using real-time color detection using webcam, as shown in Figure 3 and Figure 4.

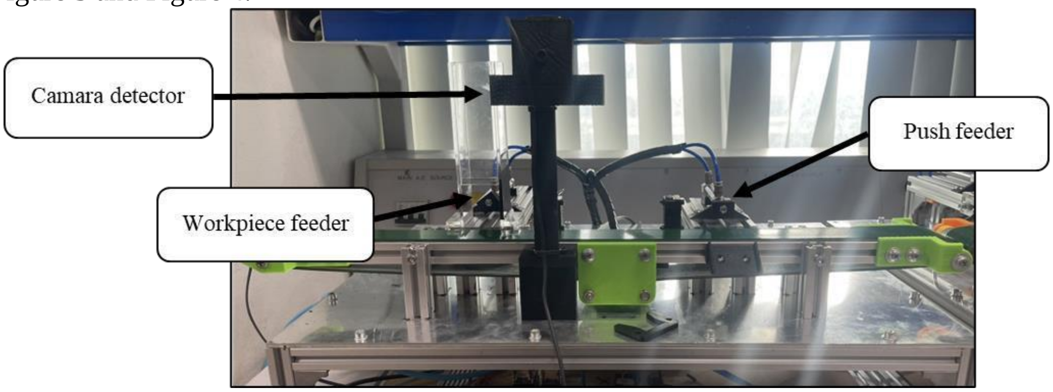

Figure 3. The structure of loading station.

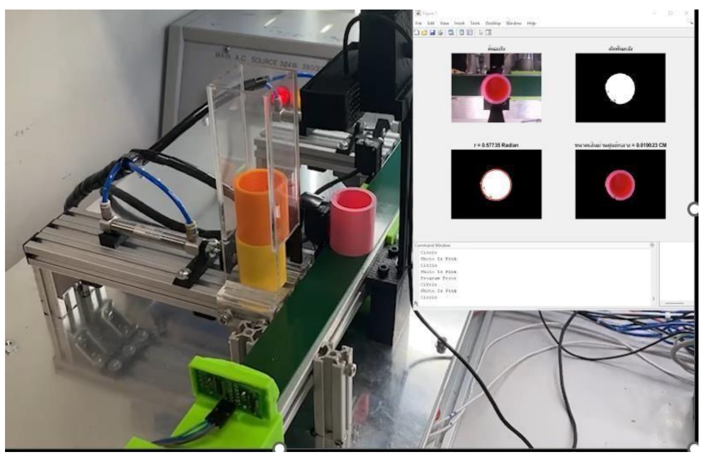

Figure 4. Real-time color detection using webcam.

3.2 Assembly Station

The assembly station is a prototype that employs the selective compliance articulated robot arm (SCARA) used for this station's pick & place and assembly operations workpiece. SCARA robot consists of two arms joined at the base and the intersection of arms one and two; it is used in assembly automation lines when coordinated with the control unit and other periphery gadgets. This station, SCARA robot, was mounted on a stable stand, pick and place robots are positioned to reach different areas to perform work. The operating status has been sent to the database and shown on the dashboard, as shown in Figure 5.

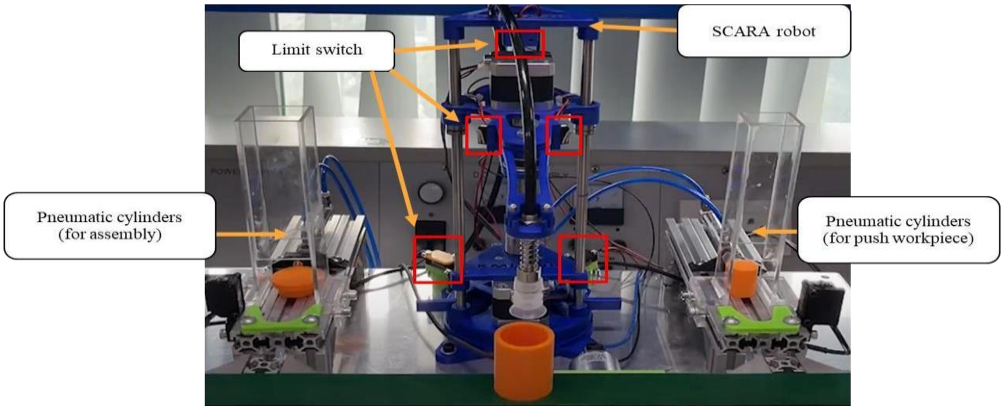

Figure 5. The structure of assembly station.

3.3 Warehouse Packing Station

The warehouse packing station is a prototype for storing goods that uses articulated robot arms with multiple joints and articulated robotic arms to move and lift items in the warehouse. It was used for moving things from pallets to racks with sensors fitted at intervals along the warehouse racking, and the system can track when the robot placed things on racks or not. The operating status has been sent to the database and shown on the dashboard, as shown in Figure 6.

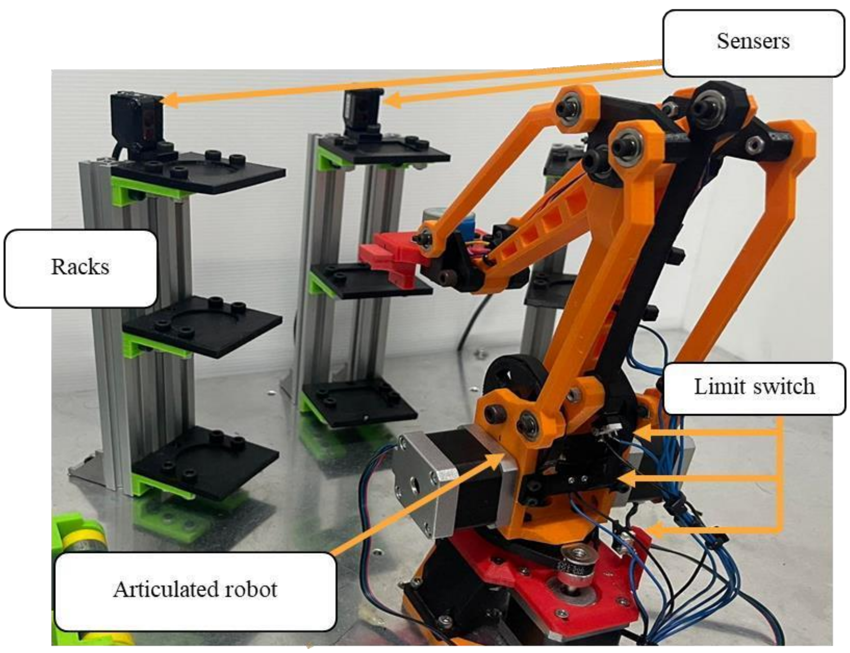

Figure 6. The structure of warehouse packing station.

3.4 Dashboard

In this work, we employ Node-RED programming tool to connect hardware devices and application programming interfaces and use database services. It can edit via the browser, making it easy to use and enter with https://nodered.org/. The information of industrial automation created in Node-RED and PLC are stored, imported, and exported for sharing information as a dashboard in the gateway connected with Open Platform Communications Unified Architecture (OPC-UA). It helps to create a live data dashboard quickly, as shown in Figure 7.

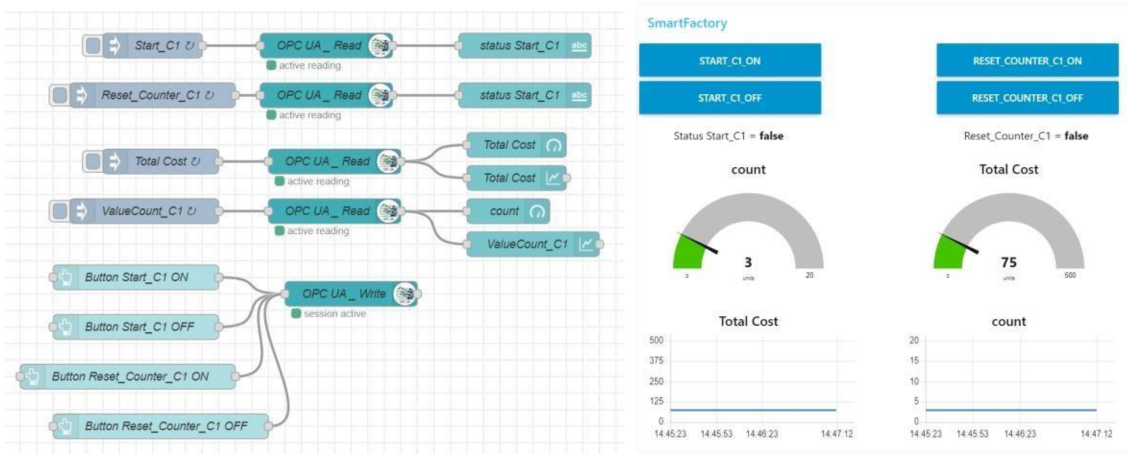

Figure 7. The illustrate of dashboard with Node-RED.

4. Conclusion and Future Work

This study offers the development of an automated manufacturing system learning kit that can be used to teach engineering education. It consists of three stations: loading, assembly, and warehouse packing. In addition, the learning factory ecosystem presented in this study aims at a much broader use of novel learning methods to introduce mechatronics engineering students to understand the new digital manufacturing process. The study results inspire instructors and educational institutions to prepare engineering students with the knowledge and practical skills based on the learning factory ecosystem. In terms of future study, to gain maximum benefit from this development in engineering education, appropriate enhancement might be to design research experiments to answer research questions and propose finding the result ultimately.

Acknowledgements

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Implementation of Smart Manufacturing System Learning Kit: Study of Engineering Teachers' Performance and Engagement

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Abstract: Nowadays, engineering education is a shift from practice-based with textbooks to practice-based with authentic materials. Especially the learning factory paradigm is a fundamental approach that refers to a realistic manufacturing environment for education, training, and industry research. However, engineering teachers experience a lack of knowledge and technology used in smart factory learning and a lack of learning material covering the industrial manufacturing content. Due to the rapid advancements in technology, there is a need to ensure that engineering teachers receive knowledge and skills that they may not have previously. This study offers three-day professional training with smart manufacturing system learning kits that can be used to encourage teachers' learning in STEM education. The participants are engineering teachers (n=38) in electronic, mechanical, and mechatronic engineering majors. The findings show practical implementation and recommendations to enhance engineering teachers' performance and engagement, which positively attitude the learning process.

Keywords: Industry 4.0, engineering education, learning factory, STEM education.

1. Introduction

Today's industry faces many challenges, such as growing technology, transformative digital transformation, and customer needs. To overcome those challenges, many enterprises must rely on industry 4.0 technology to enhance manufacturing standards, especially in developing countries that find a way to ramp up workforce production effectively (Zhang & Ming, 2021; Loumpourdi, 2021). A learning factory is a learning environment closely matching an industrial production setting to simulate production processes realistically while enabling practical training in various topics and professional levels through technologies and processes inside the learning factory based on current industry standards (Scheid, 2018). A learning factory is implementing several technologies in the industry 4.0 environment that drive existing technological developments and the ability to process large amounts of data (Centea, Singh & Elbestawi, 2019; Vijayan, Mork & Giske, 2019). The manufacturing system needs to consider Industry 4.0 to stay competitive in the market. Cause the workforce has to adapt to the workplace transformation brought by digitalization, automation, and the robotics transformation process (Rangraz & Pareto, 2021). Thus, Industry 4.0 was conducted in manufacturing enterprises where automated assembly lines, industrial robots, codes, and algorithms have replaced the manual setup.

The Thai government has implemented many policies to harness the potential of engineering education related to industry 4.0. Especially the professionalization of engineering teachers is a crucial objective in developing industrial workers. The effective mechanism induced this engineering teacherto upskill related to new technology that undertakes easy-to-achieve activities such as engineering teacher training to offset professional staff in the educational institutions necessary for sustainable growth as part of the Thailand 4.0 initiative to support economic sectors. Meanwhile, an engineering teacher instructs students in practical career skills in educational institutions. They must improve their competencies and professional training to cope with the growth of industry 4.0.

Based on the above, the authors have proposed developing a smart manufacturing system learning kit based on the learning factory paradigm for engineering teachers using learning material to connect to the learning factory paradigm. The research aims to evaluate engineering teachers' performance and engagement in smart manufacturing system training.

2. Related Work

In the last decade, the fourth industrial revolution 4.0, or industry 4.0, represents the radical transformation of an industry that has resulted from the integration of emerging technologies (Hernandez-de-Menendez, 2020). At the heart of Industry 4.0, smart factories integrate physical and cyber technologies that make the technologies more complex and precise to improve manufacturing processes' performance, quality, controllability, management, and transparency (Shi et al.,2020).

Various learning factories have been established in industry and vocational college environments to foster vocational students' competencies. Learning in realistic production environments that compete with the industry standard enables the development of problem-solving competencies among vocational students to support the industry need. Several studies address that learning factories have been an example of a good ecosystem where research and technology transfer between academia and industry happens (Ferrario el al., 2019). Learning factory concepts in the academic environment offers practice-based learning for engineering curriculum that equilibrium analytical and theoretical knowledge with manufacturing skills and hands-on experience in the design of manufacturing systems and product realization in the industrial system (Matt, Rauch & Dallasega, 2014).

In addition, the ability to connect the availability of vast amounts of data, the maturity of analytics and intelligent systems, and advanced manufacturing techniques are bringing about smart manufacturing systems (SMS) and a new data-driven era for manufacturing (Clough and Stammers, 2021).This concept applies digital technologies and consists of building a controlled workspace using a large-scale wireless technology deployment in manufacturing industries requiring a digital factory to create digital products (Tabaa, Chouri, Saadaoui & Alami, 2018).

Industry 4.0. characterized by increasing automation and the employment of manufacturing system that is integrated with operational technology and information technology to improve manufacturing operations through sensor systems and advanced data analytics in the manufacturing industry (Lenz, MacDonald, Harik & Wuest, 2020). Many studies propose the learning material for utilization in the learning process.

For example, Mourtzis, Angelopoulos & Dimitrakopoulos (2020) offered a highly automated and flexible manufacturing cell to enhance skills, competencies, and hands-on experience for a new generation of engineers. Berman, Hamidah, Mulyanti & Setiawan (2021) offered low-cost, portable air conditioning teaching and learning kits to improve students' understanding of vocational education. Mohammad et al. (2021) proposed a smart factory reference model as a guide to upgrading an existing production system towards the vision of Industry 4.0 using readily available components. It is a modular production system connected to a server accessible locally or through the internet with the application software to create the user interface. Some education institutions attempted to provide engineering teachers with opportunities for teacher professional development to maintain a standard of teaching and technical skill to cope with industrial requirements (Schmidt, 2019).

This study proposed the methodology for professional development training for engineering teachers in Thailand, including the learning activities of training modules and learning kits. Additionally, they evaluate their learning performance, whether they have achieved the educational objectives and how they think about this training.

3. Materials

3.1 Development of Smart Manufacturing System Learning Kit

In general, in teaching and learning factories for vocational education, using the existing commercial products available in the market is expensive. This study is based on a low-cost concept using a simple design and affordable materials and components intended to simulate the industry situation, allowing the students to apply their theoretical knowledge in practice. The development of a Smart Manufacturing System (SMS) learning kit consists of the three stations made of aluminum profile 20x20. Each station includes sensors (machine vision), conveyors, a selective compliance articulated robot arm or SCARA robot, articulated robot. Overall stations were controlled with a programmable logic controller (PLC) to connect hardware devices and online services through Sysmac Studio Software to support ladder, structured text, and function block programming. Furthermore, Node-RED was used to show the dashboard performed data monitoring graphically. The design basis of the smart manufacturing kit consists of three stations, as seen in Figure 1.

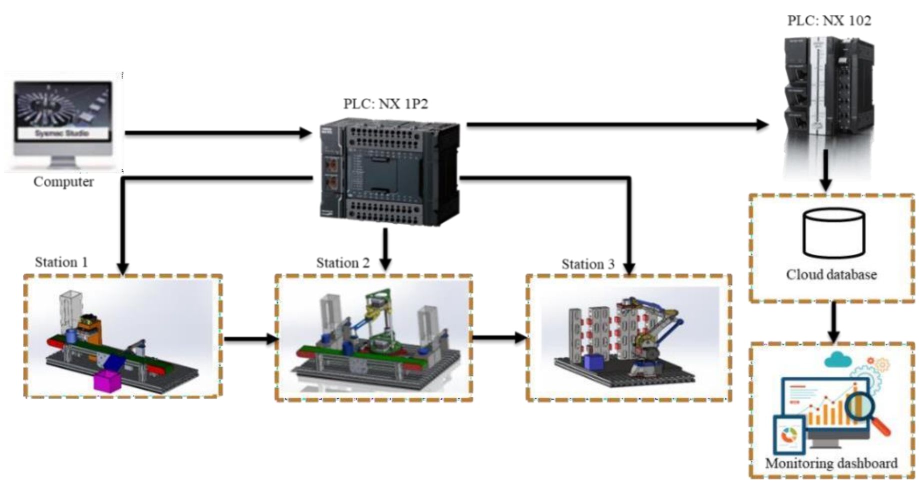


Figure 1. Design of Smart Manufacturing System schema.

Station 1: The loading station is a prototype for controlling the loading station of a factory automation system. It serves to load workpieces into the conveyors run and transport workpiece carriers. Then workpiece was then detected based on machine vision that can help achieve real-time data analysis in a manufacturing environment. It can be implemented in any industry to perform realtime monitoring of workpieces (Kumar et al., 2021). A conveyor forms for the workpiece carrier, fed to the next station as a PLC order.

Station 2: The assembly station is a prototype that employs the SCARA robot used for this station's pick & place and assembly operations workpiece. SCARA robot was used in assembly automation when coordinated with the control unit and other periphery gadgets.

Station 3: The warehouse packing station is a prototype for storing goods that uses Articulated Robotic Arms with multiple joints and articulated robotic arms to move and lift items in the warehouse. They're typically used for receiving functions, such as moving things from pallets to racks, picking, packing, and shipping.

Therefore, the concepts of this training course for using the learning activities and evaluated performance following by educational objectives are listed by topic: Manufacturing process component, Computer, and programmable logic controller (PLC) connection, PLC Ladder Programming, Programming Control Pneumatic Cylinders, Photoelectric sensor, Control of DC Motor, Vision Inspection Systems, Robot Programming Control, Vacuum Grippers control, and Design of Dashboard.

3.2 Training Module

In this study, the 3P learning module proposed by Chookaew & Howimanporn (2022) was used in the training activity to create a training module that will keep engineering Teachers motivated and engaged as follows:

Module 1: Preparing the fundamental concepts is necessary to apply knowledge into practice, especially the core concepts are basic knowledge of the manufacturing process. This module points to Industry 4.0 technology related to new technology with three stations of SMS learning kit

Module 2: Practice with the hands-on activities are tasks given to the engineering teacher to operate the manufacturing process in the industry. This module is active learning pedagogy, and industrial applications were employed to support engineering teachers' work skills. It is vital to combine concepts and practice and include active tasks that intertwine the challenges of applying theory to problem-solving in industry. They have divided into groups to perform a hands-on activity. They use Sysmac Studio software to configure and program with PLC, then use Node-RED to connect interfaces and online monitoring.

Module 3: Presentation of the training outcome. In this module, engineering teachers performed and displayed task achievement. They share knowledge and work together to present the mission of the training activity. This module can incorporate technology into engineering teacher training and create more engaging, memorable, and enjoyable training.

4. Methodology

4.1 Participants

The participants in this study were 38 engineering teachers at technical and vocational education and training colleges in Thailand. Their age was 25 to 55 years. They taught majors related to industrial technology, including mechatronics, mechanical, and electrical engineering. In addition, they had bachelor’s degrees and master’s degrees, all of which were in engineering or engineering education and averaged 5-10 years of teaching experience. The experiment was conducted in a training room equipped with a laptop and SMS learning kit.

4.2 Measuring Tools

The measurement instruments included the performance checklist to evaluate the engineering teachers’ knowledge and skills used after training activities. The performance checklists, rating scales, and rubrics are tools that state-specific criteria and allow engineering teachers to gather information and judge what they know and can do to align with the learning outcomes. It was constructed by experts who are instructors and trainers related to the smart manufacturing system. The performance checklists are clarified when engineering teachers use the criteria to evaluate performance to help them analyse each level as five levels: excellent, good, fair, marginal, and inadequate. It has 100 scores from 10 activities that cover ten concepts.

In addition, a questionnaire to evaluate the engineering teachers’ perception of the training activities. The items in this engagement questionnaire were adapted to a revised version from Chookaew et al., (2020) and translated into the Thai language. It includes three dimensions of engineering teachers’ engagements after attending the learning activity, consisting of 11 items to assess behavioral engagement (3 items), cognitive engagement (4 items), and emotional engagement (4 items). At the same time, the latter examines students’ satisfaction on 5-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = agree, 5 = Strongly Agree).

4.3 Training Procedure

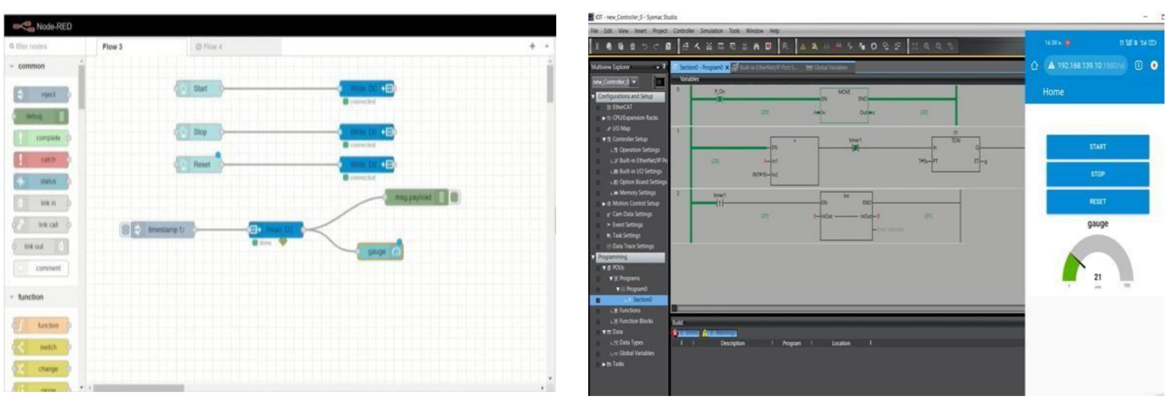
The professional development training program was implemented in a three-day workshop (a total of 28 hours). The designed training activities were separated into three days based on three learning modules as follows:

Day 1: At the beginning of engineering teacher professional development training, they participate in the preparation module with motivation learning and receive information related to the smart manufacturing concept, as shown in Figure 2.

Figure 2. The training participation of engineering teacher.

Day 2: they practiced with an SMS kit in the practice module. A worksheet is an important tool that engineering teachers use in training activities to answer questions and complete a task following a learning topic and activity. They used Sysmac Studio software of the programmable logic controller or PLC to collect sensor data from the SMS kit and then program it to control the process. After collecting data, PLC will send data to databases (Figure 3 a) through OPC-UA, allowing data analysis and visualization in real-time, supporting more significant decision-making for the smart manufacturing process.

After that, all data were created live data dashboard with Node-RED (Figure 3 b) that shows the graphic interface through which the user can visually interact with the system via mobile device. After completing each task, they evaluated performance with the knowledge and skills checklist to ensure that engineering teachers in the learning process use the training. Data were recorded through self-assessment by the participants.



(a) (b)

Figure 3. The screen shot of (a) Node-RED flow (b) Sysmac Studio and dashboard.

Day 3: Last day, they were randomly selected to showcase in the presentation module for discussion and knowledge sharing. Then, they take an engagement questionnaire.

5. Results

5.1 Engineering Teachers' Performance

The performance checklist is an instrument used to assess and provide the outcome of engineering teachers' success or failure whose performances are evaluated in the training course. The total performance score of 0–100 is according to these meanings: score ≥ 80 at an excellent level, = 79-70 at a good level, =69-60 at an acceptable level, =59-50 at a marginal level, and ≤ 49 at inadequate levels. Figure 6 shows that most engineering teachers' performance is excellent (M= 85.10, S.D.=5.65). However, only one engineering teacher has a performance score of less than 70 (acceptable level).

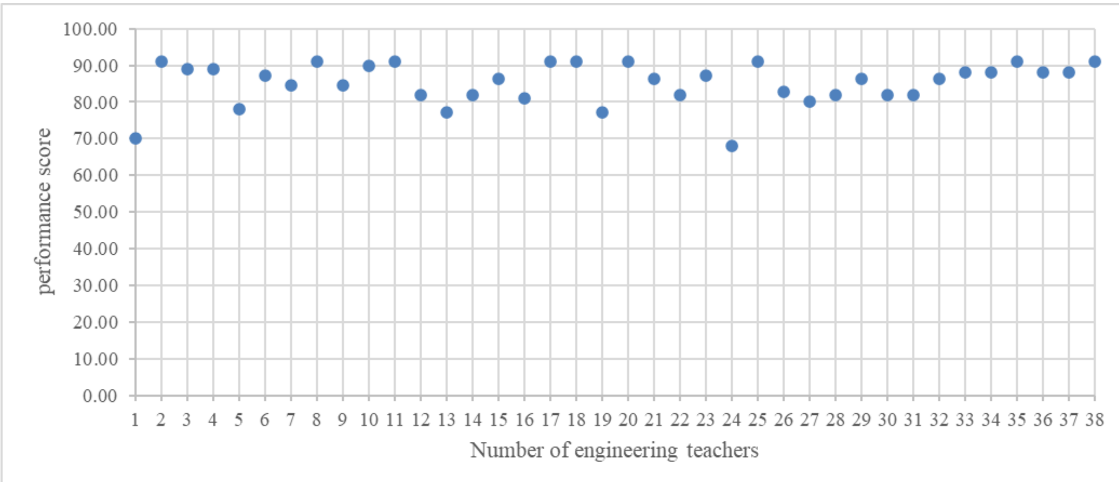


Figure 4. The engineering teachers' performance.

5.2 Engineering Teachers' Engagement

The second research objective is to evaluate engineering teachers' engagement in training activities. It consists of 11 items that could be scored on a 5-point Likert scale from 1 (Strongly disagree) to 5 (Strongly agree). When analysing the engagement questionnaire, descriptive statistics are used to describe mean scores, where 1–1.5 represents "strongly disagree," 1.51–2.50 represents "disagree," 2.51–3.50 represents "neutral," 3.51–4.00 means "agree," and 4.01–5.00 represent "strongly agree." For the result of engineering teachers' engagement in training activities, see Table 1.

Table 1. *Result of the engineering teachers' engagement in training activities*

Item	Mean	S.D.	Remark
Behavioral Engagement	*4.18*	*0.90*	*Agree*
1. I can participate and work in a training activity.	4.27	0.79	Agree
2. I attempt to define and discuss the task.	4.24	0.82	Agree
3. I think an environment is not a barrier to my learning.	4.03	1.05	Agree
Cognitive Engagement	*4.09*	*0.99*	*Agree*
4. I think the smart manufacturing system learning kit improves my thinking process and work related to the learning factory paradigm.	4.49	0.64	Agree
5. When I am unsure about the concept in training, I always consult a mentor.	3.86	0.99	Agree
6. When the problem occurs, I attempt to find the solution myself.	4.00	1.04	Agree
7. I always plan before operating in an activity with the smart manufacturing system learning kit.	4.00	1.09	Agree
Emotional Engagement	*4.26*	*0.85*	*Agree*
8. I think I can apply the smart manufacturing system learning kit in my teaching	4.16	0.85	Agree

9. I feel that the smart manufacturing system learning kit is a challenge for me.	4.24	0.88	Agree
10. I prefer the smart manufacturing system learning kit.	4.27	0.79	Agree
11. I think the smart manufacturing system learning kit gives me the knowledge and has a connecting learning factory paradigm as well.	4.38	0.85	Agree

In table 1, the engineering teachers' behavioral engagement dimension (M= 4.18, S.D. = 0.90), they interested in training activity, while the engineering teachers' emotional engagement dimensions were agreed (M= 4.09, S.D. = 0.99), and the engineering teachers' cognitive engagement dimensions were agreed (M= 4.26, S.D. = 0.85), respectively.

In addition, semi-structured interviews about how to think training activities served as the research method used in this study. Three participants selected who have outstanding were interviewed individually. The interviews lasted approximately 5 to 10 min. In this group of engineering teachers, the common view was that they all acknowledged their engagement in training activities with a positive attitude as follows:

Engineering teacher A: *"I think this training is an opportunity to open new technology to practice learning that they found most efficient in their vocational development into industrial 4.0."*

Engineering teacher B: *"I usually feel nervous about new technology because it is challenging to learn and teach, but I learned this course; I think it is easy if I have learning material to connect concepts and practices."*

Engineering teacher C: *"When I do many tasks in the training module, I have always been lazy. I think that I do not remember any content, but I try to pass it. At last, I can do it. However, I think this training takes a short time."*

6. Conclusions and Limitations

This study is an important mechanism for the engineering teachers' professional development, providing opportunities for learning any employable new skills related to STEM education. The finding has examined engineering teachers' performance and engagement in professional development training using a smart manufacturing system learning kit. To encourage the capacity to interconnect learning and the teaching/transferring of the engineering teacher. In addition, the organization is aware of professional development and capitalizes on developing teachers who function as potential workers and create new pedagogical practices.

The critical discovery limitation from this study is an unsatisfied demand number of learning kits in activities that impact individual engineering teachers' perception of the activity they have participated in the training. In addition, the research design and the participants' sample size limit robust statistical analysis and results to an extent.

Acknowledgements

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Developing Pre-Service Science Teachers' TPACK Self-Efficacy of Chemistry Competencies through Case-based Learning Intervention

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Abstract: Technological Pedagogical and Content Knowledge, called TPACK, is essential for 21st chemistry teachers since technologies can enhance science teaching and learning quality if appropriately implemented. Meanwhile, developing students' competencies in science are required to respond to social needs. Due to that challenge, this study focuses on preparing preservice science teachers to promote students' chemistry competencies through TPACK training. In this study, 32 pre-service science teachers from Chemistry Education Department, Yogyakarta State University, Indonesia, were invited. This study used a quasi-experimental research design to collect data before and after the intervention. The results revealed significant differences between pre-service science teachers' TPACK self-efficacy scores at the pretest and post-test.

Keywords: TPACK, chemistry competency, self-efficacy, digital technology, case-based learning

1. Introduction

Undoubtedly the Circular Economy is a promising approach to sustainable development. To be active citizens, students must have competencies to sustain our environment, and teachers must equip them with competencies to achieve the goal. In terms of chemistry education, the most recent version of the Chemistry Curriculum in Senior High School that emphasizes chemistry competencies has been established in China to meet this challenge. Furthermore, other developing countries worldwide, including Indonesia, can adapt the curricula.

Meanwhile, technological advancement has inevitably led to the transformation of all disciplines. In terms of the chemistry classroom, Nugraheni, Adita, & Srisawasdi (2020) stated that technology could support various learning strategies to teach chemistry. Hence, teachers can apply several technologies to assist students in achieving these chemistry competencies (Nugraheni, Prasongsap, & Srisawasdi, 2021). To achieve this goal, teachers should appropriately integrate technologies in their chemistry classrooms. Nevertheless, several previous studies (e.g., Niess, 2005; Angeli & Valanides, 2009; So & Kim, 2009) indicated that teachers had difficulties integrating technologies in their classrooms to teach specific content, particularly in determining the most effective teaching tool. Moreover, due to the lack of pedagogical knowledge, teachers sometimes unsuccessfully effectively integrate technology into their classroom instruction (Hew & Brush, 2007; Kramarski & Michalsky, 2010, Chai, Koh, & Tsai, 2013; Cetin-Dindar et al. (2017)). Many researchers proposed that pre-service teachers require TPACK training to deal with this obstacle throughout their initial education. For instance, Cetin-Dindar et al. (2017) conducted a course to integrate various technologies (e.g., animations, data logging, instructional games, simulations, virtual lab, virtual trips) into the chemistry classroom. The results revealed that some TPACK components on pre-service chemistry teachers can be improved by the implementation of the intervention. In addition, Zimmerman, Melle, & Huwer (2021) developed a university seminar for prospective chemistry teachers' professionaldevelopment. The results revealed that the seminar appropriately fosters pre-service chemistry teachers' TPACK. However, there is no research about TPACK that focuses on chemistry competencies. Hence, TPACK training, especially for preparing pre-service science teachers to foster students' chemistry competencies, is prominent to be conducted. As above mentioned, a research question is does a case-based learning intervention affect changes in pre-service teachers' TPACK self-efficacy of chemistry competency? and a hypothesis of this study is the case-based learning intervention could improve pre-service teachers' TPACK self-efficacy of chemistry competency.

2. Literature Review

2.1 Technological Pedagogical and Content Knowledge (TPACK)

In 2006, Mishra and Koehler introduced Technological Pedagogical Content Knowledge (TPACK) as a conceptual framework. This framework was based on Shulman's (1986) Pedagogical Content Knowledge (PCK). TPACK describes the integration of technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK). Furthermore, the framework describes the prominent knowledge of how teachers could integrate technology to teach specific subject content with specific pedagogies in their classrooms (Jimoyiannis, 2010; Srisawasdi, 2012).

TPACK comprises seven constructs. Each construct can be defined as follows: (1) Content Knowledge (CK) refers to the knowledge of the subject matter to be studied or instructed; (2) Pedagogical Knowledge (PK) refers to the knowledge of the methods of classroom practices (instructional methods); (3) Technological Knowledge (TK) refers to the knowledge of technologies as well as the skills required to operate technologies, (4) Pedagogical Content Knowledge (PCK) refers to knowledge of specific teaching practices that are appropriate for specific subject content, (5) Technological Content Knowledge (TCK) refers to the knowledge of how technologies can be used to manipulate specific subject content into appropriate representations (6) Technological Pedagogical Knowledge (TPK) refers to the knowledge of the specific technologies that can be used to support the teaching and learning processes; and (7) Technological Pedagogical Content Knowledge (TPACK) refers to the knowledge of how to use appropriate technologies to support learning of content through specific pedagogical strategies (Mishra and Koehler, 2006). Figure 1 depicts the TPACK framework proposed by Mishra and Koehler (2006).

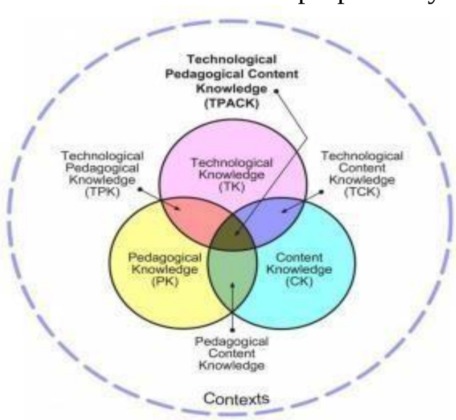

Figure 1. TPACK Framework (Mishra and Koehler, 2006).
(http://tpack.org)

2.2 Technological Pedagogical and Content Knowledge emphasized Chemistry Competencies (TPACK-CC)

TPACK-CC is TPACK that focuses on Chemistry Competencies. This study followed six chemistry competencies. Five chemistry core competencies are adapted from China Senior High School Chemistry Curriculum as follows:" macroscopic identification and microscopic analysis (C1), changesand equilibrium (C2), evidence-based reasoning and modeling (C3), scientific inquiry and innovation (C4), scientific attitude and social responsibility (C5) (Wei, 2019)." Meanwhile, the sixth competency (C6) (i.e., the link between macroscopic, microscopic, and symbolic) was developed by Nugraheni, Prasongsap, & Srisawasdi (2021).

According to the learning matrix developed by Nugraheni, Prasongsap, & Srisawasdi (2021), TPACK-CC in this study is divided into three clusters. The first cluster is TPACK-CC, which focuses on C1 & C2. The second cluster is TPACK-CC, which focuses on C3 & C6. Furthermore, the third cluster is TPACK-CC, which focuses on C4 & C5. This paper merely describes the first cluster. In the first cluster, C1 and C2 are defined as CK. Meanwhile, TK is a 360^o camera and vivista software. Furthermore, the PK is guided inquiry.

3. Methodology

3.1 Sample

In this research, 32 pre-service science teachers from Chemistry Education Department, Yogyakarta State University, Indonesia, were invited. They were 28 (87.5 %) females and 4 (12.5%) males. All of the participants are in their second year. The participants' average age is between 21 and 22 years old. All participants in this study had previously completed courses related to chemistry (e.g., General Chemistry, Organic Chemistry, Analytical Chemistry, and Physical Chemistry), general pedagogical courses (e.g., Introduction to Education, Educational Psychology), and subject-specific pedagogical courses (e.g., Strategy of Chemistry Teaching, Curriculum of Chemistry).

3.2 Research Design

This study employed a quasi-experimental research design, in which data were collected before and after the intervention. The implementation of the intervention followed the "SPA" model (Pondee, Panjaburee , & Srisawasdi, 2021). Table 2 shows the details of the intervention.

Table 1. *The Details of Intervention*

Phase	Day	Topic	Learning Strategy	Knowledge Domain
Showing the Case (S)	1 (1 hour)	Showing some successful cases of using 360^o video in the chemistry laboratory	Interactive lecture	CK, TK, TCK
Practice in Team (P)	1 (3 hours)	Practicing 360^o camera to make 360^o video in the chemistry laboratory	Hands-on practical work	CK, TPK, TPACK
	2 (1 hour)	Enriching 360^o video with vivista	Hands-on practical work	CK, TPK, TPACK

Application of the Case (A)	2 (3 hours)	Designing a lesson plan to foster students' chemistry competencies	Hands-on practical work	CK, TK, PK, TCK, TPK, PCK, TPACK

Figure 2. An illustration of the S phase, showing some successful cases of using 360° video in the chemistry laboratory.

In the S phase, the instructor presented four successful research cases of using 360° video in the chemistry laboratory, as shown in Figure 2. All of the cases addressed the difficulties of chemistry learning in the chemistry laboratory by using 360° video.

Figure 3. An illustration of the P phase, practicing 360° camera to make 360° video in chemistry laboratory (left), enriching 360° video with vivista (right).

In the P phase, the pre-service science teachers were assigned to record 360° video in the chemistry laboratory using 360° camera, as shown in Figure 3. Then, they were asked to enrich the video by using vivista software.

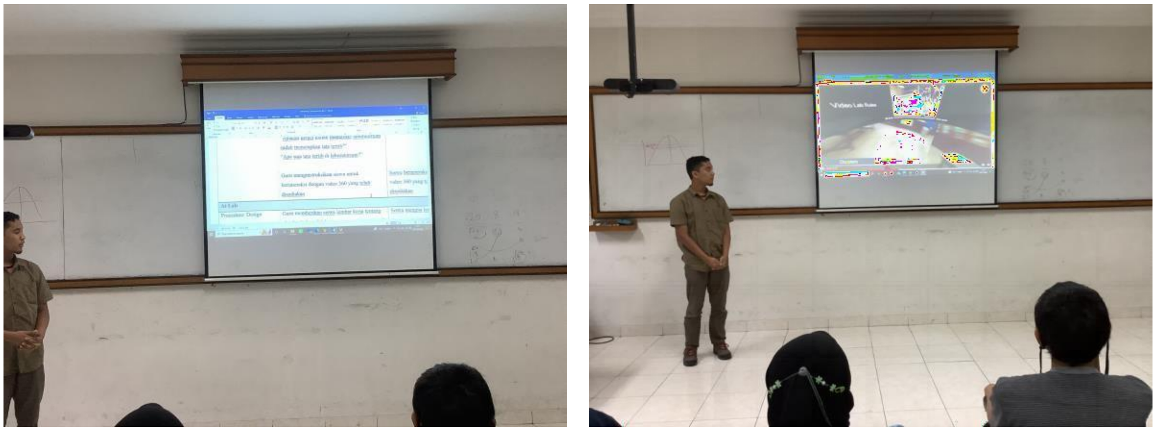

Figure 4. An illustration of the A phase, designing a lesson plan to foster students' chemistry competencies by integrating 360º video and vivista into the learning activity.

In the A phase, the pre-service science teachers were instructed to design lesson plans to foster students' chemistry competencies by integrating 360º video and vivista into the learning activity, as shown in Figure 4.

3.3 Data Collection

This study investigated the effect of implementation intervention on pre-service science teachers' TPACK self-efficacy. TPACK self-efficacy questionnaire was employed in this study. The questionnaire was adapted from Schmidt et al. (2009). The questionnaire consists of 28 items. These instruments followed seven constructs of TPACK (i.e., TK, CK, PK, TPK, TCK, TPK, TPACK). The survey was presented with a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Furthermore, the Cronbach's alpha values of each item, as shown in Table 2.

Table 2. *Cronbach's alpha values of each item*

Item	Cronbach's alpha	
	Pretest	Posttest
1	0. 93	0.92
2	0.93	0.92
3	0.92	0.92
4	0.92	0.93
5	0.92	0.93
6	0.92	0.92
7	0.92	0.92
8	0.92	0.92
9	0.92	0.92
10	0.92	0.92
11	0.92	0.92
12	0.92	0.92
13	0.92	0.92
14	0.92	0.92
15	0.92	0.92
16	0.92	0.92
17	0.92	0.92

18	0.92	0.92
19	0.92	0.92
20	0.92	0.92
21	0.92	0.92
22	0.92	0.92
23	0.92	0.92
24	0.92	0.92
25	0.92	0.92
26	0.92	0.93
27	0.92	0.92
28	0.92	0.92
Overall	0.92	0.92

The Cronbach's alpha values in the table indicate that the internal consistency of this instrument is good.

6. Results and Discussion

The intervention's effect on pre-service science teachers' TPACK-self efficacy for each component is shown in Table 3.

Table 3. *The mean of each factor at pre-test and post-test*

Aspect	Item	Pretest		Posttest	
		Mean	SD	Mean	SD
TK	Item 1	2.47	0.72	4.06	0.35
	Item 2	3.47	0.76	4.28	0.46
	Item 3	2.66	0.55	3.97	0.47
	Item 4	2.38	0.66	3.69	0.74
	Item 5	2.47	0.62	3.88	0.49
	Item 6	2.84	0.68	4.09	0.39
	Item 7	3.47	0.80	4.03	0.54
	Average	2.82	0.68	4.00	0.49
CK	Item 1	3.22	0.66	3.94	0.44
	Item 2	3.53	0.57	4.09	0.30
	Item 3	3.16	0.63	3.97	0.47
	Average	3.30	0.62	4.00	0.40
PK	Item 1	3.16	0.57	3.97	0.59
	Item 2	3.31	0.78	4.09	0.39
	Item 3	3.41	0.76	4.09	0.39
	Item 4	3.13	0.75	4.06	0.44
	Item 5	3.28	0.73	4.09	0.30
	Item 6	2.94	0.72	3.72	0.63
	Average	3.21	0.72	3.43	0.46
PCK	Item 1	3.13	0.66	4.03	0.40
TCK	Item 1	3.06	0.67	4.09	0.30

TPK	Item 1	3.34	0.60	4.00	0.44
	Item 2	3.13	0.66	4.16	0.37
	Item 3	3.59	0.56	4.13	0.42
	Item 4	3.53	0.57	4.06	0.56
	Item 5	3.38	0.55	4.06	0.50
	Item 6	3.38	0.49	4.03	0.40
	Item 7	2.97	0.78	4.16	0.45
	Item 8	2.81	0.74	3.91	0.47
	Item 9	3.13	0.83	4.03	0.40
	Average	3.25	0.64	4.06	0.44
TPACK	Item 1	2.84	0.85	4.06	0.35

Table 3 shows the descriptive analysis for each item in all components. As seen in table 3, the mean of all items in all components (TK, CK, PK, PCK, TCK, TPK, and TPACK) increases based on pre-service science teachers' pretest and post-test. The highest increase is in TPACK construct, while the lowest increase is in PK construct. Furthermore, the overall results as shown in Table 4.

Table 4. *Wilcoxon signed-rank test*

Test	N	Mean	SD	Z	Asymp.Sig. (2-tailed)
Pre-test	32	3.11	0.68	-4.94	0.000
Post-test	32	4.03	0.44		

To examine the differences between the pretest and post-test, Wilcoxon signed rank was employed since the data were not normally distributed. According to table 4, the value of Asymp.Sig. (2-tailed) is 0.000. Since 0.000 is lower than 0.05, so alternative hypothesis (Ha) is accepted. It indicates that there is a statistically significant difference between the pre-test and post-test.

In a nutshell, the findings of this study indicated that the intervention could enhance pre-service science teachers' TPACK self-efficacy. It is in line with some previous studies (i.e., Cetin-Dindar et al., (2017); Zimmerman, Melle, & Huwer (2021)). Cetin-Dindar et al. (2017) conducted a course to integrate various technologies (e.g., animations, data logging, instructional games, simulations, virtual lab, and virtual trips) into the chemistry classroom. The findings revealed that some TPACK components on pre-service chemistry teachers can be improved by the implementation of the intervention. In addition, Zimmerman, Melle, & Huwer (2021) developed a university seminar for pre-service chemistry teachers' professional development. The results revealed that the seminar appropriately fosters pre-service chemistry teachers' TPACK self-efficacy. Both studies employed the same instrument with this study to measure pre-service chemistry teachers' TPACK self-efficacy.

7. Conclusion

This study investigates the leveraging of TPACK-CC training on pre-service science teachers' TPACK self-efficacy. The findings revealed a significant difference between their TPACK-self-efficacy scores at the pretest and post-test. The results indicate that the intervention enhanced pre-service science teachers' TPACK-CC.

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Plastic Island Game: A Digital Game for Facilitating Citizen Inquiry Pedagogy in School Science Education

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Abstract:
Promoting essential skills to fulfill 21st-century learning goals is undeniable. Using contextual issues as the topic for learning and citizen inquiry as a pedagogy can be considered an alternative approach for students learning in science to achieve their goals. In addition, active learning in a contextual issue, such as the environment, will give students benefits for meaningful learning. However, few technologies supported citizen inquiry learning with specific topics are available. Hence, developing technology for supporting citizen inquiry is beneficial for students and teachers. In designing the game, the researchers must focus on inquiry steps and involve socio- scientific issues to achieve meaningful learning. This paper focuses on implementing a digital game as technology to support citizen inquiry which aims to evaluate the game quality and assess pre-service science teachers' motivation and self-efficacy toward implementing citizen inquiry. Based on the results, the quality of the game categorizes as good, and pre-service teachers' motivation shows that intrinsic motivation outnumbers extrinsic motivation. At the same time, pre-service teachers' self-efficacy shows a good result, with mean scores exceeding three on a scale of 1 to 5. The findings imply that digital game technology can be used in teacher professional development, especially to train teachers or pre-service teachers in the inquiry or citizen inquiry context.

Keywords: Citizen inquiry, Inquiry-based learning, Digital game, Pedagogical application, Microplastic

1. Introduction

Learning science through inquiry is not a new thing anymore. As Chiang et al. (2014) mentioned, many countries incorporated inquiry learning in the range of K-12 education. However, the result of students' achievement in learning science is still below the standard line (PISA); a case in Indonesia's mean score for science performance is 396 below the OECD average, which is 489. In addition, (Paidi et al., 2020) also stated that students' cognitive achievement in Indonesian high school students is not satisfactory. The findings indicate worrisome results in learning and teaching science. This problem becomes a big issue considering the future aims of teaching and learning science. As mentioned in OECD in the following education outcome, the important thing for students is to achieve well-being by using meaningful learning (OECD, 2019). Mason et al. (2019) also explained that the future direction of education is appropriate pedagogy to foster the growth of an individual or person. One of the pedagogies for the future trend is citizen inquiry (Mason et al., 2019) which is scientific inquiry investigations involving the public's participation. Results show that socio-scientific issues implement in the citizen inquiry (McKercher et al., 2017; Sharples et al., 2017; Forrest et al., 2019).

Based on the previous study (Adita et al., 2021), one of the possible technologies is a digital game. The digital game has many advantages, such as improving student learning (Qian & Clark, 2016) and providing various educational experiences (Srisawasdi & Panjaburee, 2019). Therefore, using the digital game in learning science is an opportunity peculiarly to accommodate the digital native. In addition, integrating the digital game with inquiry pedagogy has been proven to affect students' achievement to transform the concept of science (Srisawasdi & Panjaburee, 2019). Importantly, using learning strategies such as inquiry in mobile based-learning was still low implemented from 2007-2016 (Chang & Hwang, 2019).

This study also stated that through digital games, the role of the teacher in conducting learning is still important. Therefore, in this study, the researchers develop a game that does not eliminate teacher existence. Also, the game can be integrated with the hands-on experiment activity in a practical laboratory if learning by doing and directly in the experiment is meaningful for students. The inquiry method embedded in this game involves several steps students need to accomplish the game. Although the researchers used the term citizen inquiry in this research, this did not engage public participants in this study. However, it is possible to do in the future direction.

In addition, in the paper, the researchers describe how the pre-service teachers evaluate the plastics island game and their motivation and self-efficacy toward implementing citizen inquiry. Rotman et al. (2014) motivation in citizen science or citizen inquiry is dynamic and changes over time. Hence, it is essential to know pre-service teachers' motivation toward implementing citizen inquiry for future teacher professional development suggestions. Besides, the researchers also measure pre-service teachers' self-efficacy to conduct citizen inquiry. In citizen inquiry, self-efficacy is the degree of pre- service teachers' confidence to participate in citizen inquiry (Phillips et al., 2017).

2. Literature Review

2.1 Understanding of Inquiry and Citizen Inquiry

To understand citizen inquiry, all need to know inquiry learning. Inquiry-based learning as a pedagogy was established a long time in line with the development of science. Many studies revealed that inquiry could enhance quality learning. There are several models in inquiry-based learning. In this paper, the type of inquiry differentiates by inquiry-type laboratories. According to Banchi and Bell (2008), there are four levels of scientific inquiry for learning: confirmation, structured, guided, and open. At the same time, Buck et al. (2008) stated that there are five levels of scientific inquiry: confirmation, structured inquiry, guided inquiry, open inquiry, and authentic inquiry. There are many versions of the steps of inquiry. However, a study by (Pedaste et al., 2015) stated that although there are differences between levels of inquiry. The main steps are still the same: Orientation, Conceptualization, Investigation, Conclusion, and Discussion.

Inquiry investigation with public participation is citizen inquiry. Citizen inquiry is citizen science's activity involving public participation led by scientific inquiry investigations (Herodotou et al., 2014). The public will contribute data to the scientist and apply it in their scientific research. (Herodotou et al., 2017). In addition, citizen inquiry allows people to work as a community and share their thoughts and knowledge on the topic people are interested in (Aristeidou et al., 2013).

According to (Adita et al., 2021), several technologies can support citizen inquiry. Citizen inquiry allows students to tackle the problem with an online-based platform. Hence, the learning activities become community-oriented (Aristeidou et al., 2013). Using technology in implementing citizen inquiry has several positive impacts, such as giving students authenticity (Ellenburg et al., 2019), experience, and raising students' awareness (Buchanan, Pressick-Kilborn, & Maher, 2018).

2.2 Learning Science through Digital Game

Learning through digital games can be one of the alternatives to provide students learning experience to cope with the problem related to the subject-specific content (Tapingkae, Panjaburee, Hwang, & Srisawasdi, 2020). As Prensky (2001a) mentioned, digital game-based learning combines serious learning,

engagement, interactive learning, and fun. According to (Qian & Clark, 2016), using the digital game in education has affected student learning significantly compared to non-game conditions.
Also, using a digital game can improve theoretical thinking skills significantly (Hussein et al., 2019)

According to (Srisawasdi & Panjaburee, 2019), game-transformed, inquiry-based learning can enhance conceptual understanding and motivation to learn chemistry. Open inquiry is acknowledged as a model to induce the student's progression toward scientific conceptual understanding (Srisawasdi & Kroothkeaw, 2014). Various game elements, including scoreboards, storylines, quests, contextualized feedback, and non-linear exploration of information used to support three core features of inquiry-based learning (Gao et al., 2019). While Chen, Huang & Liu (2019) suggested that the group that followed the predict-observe-explain (POE) inquiry scaffolds guide performed significantly better in both conceptual understanding and game performance.

Previous research (Adita et al., 2021) suggests that digital games can be applied in outclass activities. Meanwhile, the researchers can use hands-on experiment experiences in the in-class activity. The researchers proposed combining digital games with hands-on experiments in this design to give students new experiences. Then, digital games embedded with hands-on experiments potentially can achieve essential skills to be well-being students.

3. Methods

3.1 Sample Descriptions

A total of 21 pre-service science teachers participated in this study, consisting of 81% female and 19% male participants. The participants are majoring in general science in the second-and third-year grades. The researchers conducted two days of implementation in this implementation using the plastics island game.

3.2 Data Sources

3.2.1 Pre-service Teachers' Evaluation toward Plastics Island Game

The instrument was adapted from De Araujo Lima et al. (2022), and the instrument was translated into Indonesian by the researchers. This questionnaire consists of 12 items scored on a five-point Likert scale in which "5" represent "Strongly Agree," "4" represents "Agree," "3" represents "Neutral," "2" represents "Disagree," and "1" represents "Strongly Disagree." The test consists of twelve items with four dimensions: four items of interface components, four items of playability components, three multimedia components, and one item of games' story components. The instrument's internal consistency by Cronbach alpha is 0.872, indicating that the instrument has good reliability. In addition, in this study, the researchers also used an interview sheet with two questions on the game's evaluation. The interview took 15 minutes with four people as volunteers.

3.2.2 Pre-service Teachers' Motivation and Self-efficacy toward Implementation of Citizen Inquiry

The 5-point Likert scale questionnaire of motivation and self-efficacy toward implementing citizen inquiry was adapted from (Phillips et al., 2017). Then, translated into the Indonesian language by researchers. This questionnaire consists of 14 items scored on a five-point Likert scale in which "5" represent "Strongly agree," "4" represents "Agree," "3" represents "neutral," "2" represents "Disagree," and "1" represents "Strongly Disagree." The internal consistency of the motivation and self-efficacy questionnaire by Cronbach alpha is 0.781 and 0.836, respectively, implying that the instrument has good reliability.

3.2.3 Designing Digital Game based on Inquiry Practices

Previous research (Adita et al., 2021) shows that technology such as digital games can support citizen inquiry lessons. In this paper, the researchers highlight that the digital game in this research focuses on all the topics of microplastics compared to the previous analysis results (Adita et al., 2021). The digital game is only used on the issues impacting microplastics to the environment and human health (see table 1.1). This game has six missions embedded with the inquiry steps and hands-on experiment activity on four tasks. The actions of inquiry are stated clearly in the game interface: background information, asking questions, providing possible hypotheses, collecting the data/evidence, analyzing the data, and communicating the data. Figure 1 displays illustrative examples of the game on smartphones.

Figure 1. An illustration of the Plastic Island game: a video presentation of the problematic issue on plastic (left) and an inquiry-based investigative mission on the plastic waste situation (right)

For the implementation of the game, teachers have a pivotal role in guiding the students to complete the mission, especially in collecting evidence, analyzing data, and communicating the data. Based on the previous research by (Srisawasdi & Panjaburee, 2019), teachers' roles are in the pre-gaming and post-gaming phases, which consist of an open-ended question and introductory background whole post- gaming phase consists of results communication and conclusions. In this research, the teachers' role is to guide the experiment's steps, collect the data, and discuss the results and conclusions.

Table 1. *Descriptions of digital game content in the microplastics topics*

Topics of Microplastics	**Digital Game Content**					
	Mission					
	1	**2**	**3**	**4**	**5**	**6**
What is Microplastics	Hands-on Experiment (Observing Fish Fesses)	Hands-on Experiment (Cosmetics Products Filtration)				
How to Identify Microplastics			Hands-on Experiment (Simple Identification)			
How to Collect Microplastics				Hands-on Experiment (Collecting Microplastics with Ferrofluid)		

Impact of Microplastics to the Environment and Human Health		Video (River pollution in Indonesia)	Quiz (Drag and drop)
Competencies	**Microplastics Competencies**		

4. Results and Discussion

4.1 Pre-service Teachers' Evaluation toward Plastics Island Game

In this implementation, the researchers ask students to evaluate a plastics island game with four dimensions: interface, playability, multimedia, and story. Based on those criteria, the highest mean score was multimedia (Mean = 4.25, S.D. = 0.43), playability (Mean = 4.20, S.D. = 0.56), game's story (Mean = 4.10, S.D. = 0.77), and interface (Mean = 4.02, S.D. = 0.58), respectively. In addition, in this study, the researchers also interviewed four people as a volunteer in terms of game evaluation. Based on their argument, they were pretty satisfied with the game integrated with the inquiry steps, especially with the hands-on experiment embedded in the game design. However, there are drawbacks that researchers found during implementation, which are a slow internet connection and a short time of implementation. They argued that it needs a long time of training to operate the game, especially with the hands-on experiment. Figure 2 illustrates the results of pre-service teachers' evaluation regarding the four criteria.

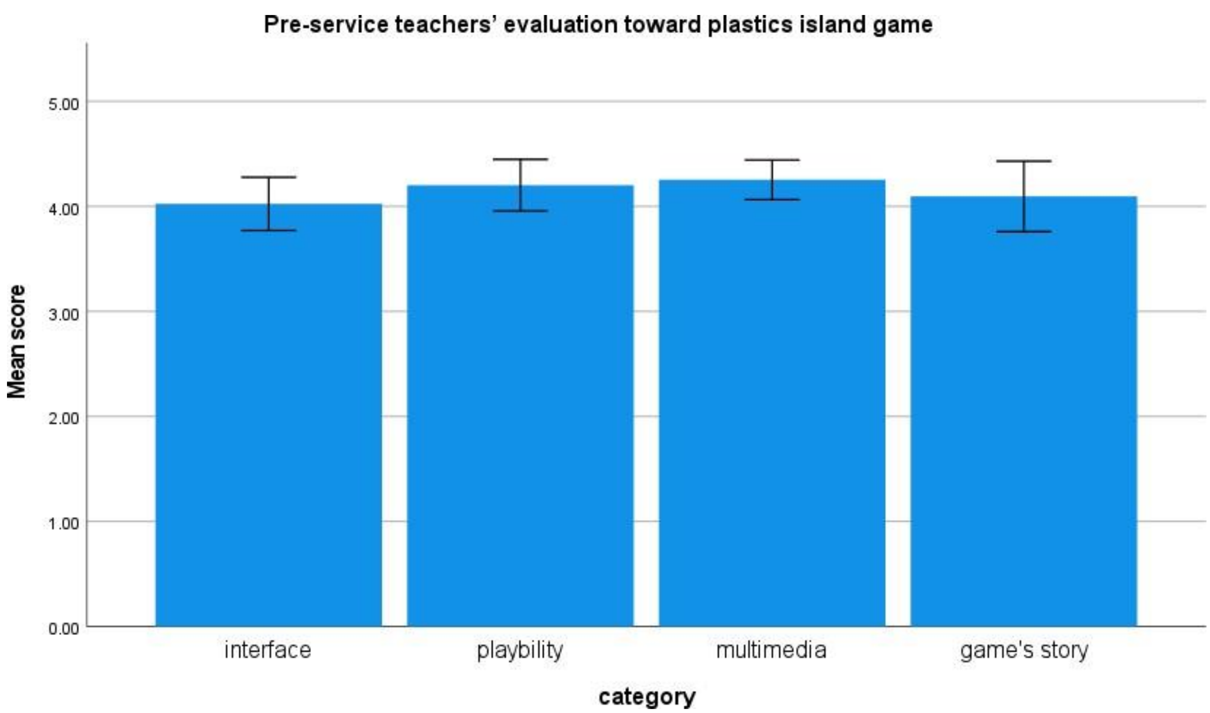

Figure 2. Pre-service teachers' evaluation of Plastics Island game

4.2 Pre-service Teachers' Motivation and Self-efficacy toward Implementation of Citizen Inquiry

This research also measures pre-service teachers' motivation toward implementing Citizen Inquiry. It is crucial to know the motivation of pre-service teachers toward Citizen Inquiry. Phillips et al. (2018) mentioned that motivation and self-efficacy are key potential outcomes of participating in citizen science. Table 2 categorizes motivation into two components: intrinsic and extrinsic motivation. In this research, pre-service science teachers' intrinsic motivation (Mean = 3.92, S.D. = 0.57) exceeds extrinsic motivation (Mean = 3.52, S.D. = 0.72). The data shows that pre-service teachers are more conscious of implementing citizen inquiry. In other words, pre-service teachers recognize that the activity is essential to achieve their goal instead of feeling fear or avoiding or having a negative feeling. Ryan and Deci (2000a; 2000b) also stated that a more intrinsically motivated person would have more effort and persistence for a particular activity. Motivation will drive students to engage more in citizen inquiry (Phillips et al., 2018).

Table 2. *Intrinsic and Extrinsic Motivation Scores in Implementation of Citizen Inquiry*

	Mean	Standard deviation
Intrinsic motivation	3.92	0.57
Extrinsic motivation	3.52	0.72

Phillips et al. (2018) also stated that motivation for citizen sciences is dynamic and complex. Therefore, motivation in the citizen inquiry is one of the variables that need to be measured to develop citizen inquiry in the future. Regarding self-efficacy, the pre-service teachers perceived their feeling about learning and understanding science content (Mean = 3.45, S.D. = 0.88) as equal to their feeling about doing citizen science activities (Mean = 3.51, S.D. = 0.96). Table 3 shows the results of pre- service teachers' self-efficacy in the pedagogy of citizen science or inquiry.

Table 3. *Pre-service Teachers' Self-Efficacy Scores regarding Citizen Science/Citizen Inquiry*

	Mean	Standard deviation
Pre-service teachers' feelings about learning and understanding science content	3.45	0.88
Pre-service teachers' feelings about doing citizen science activities	3.51	0.96

Another essential variable for citizen science is students' self-efficacy or a person's beliefs. In the context of citizen science, self-efficacy is very important in carrying out the principal activity (Crall et al., 2011). Also, self-efficacy indicates that students are confident about participating in the citizen project (Phillips et al., 2018). In this research, pre-service teachers' self-efficacy is categorized into two groups: pre-service teachers' feelings about learning and understanding science content and feelings about doing citizen science activities. Based on the table, there are slight differences between the two groups. However, both groups have a mean score surpassing three on a scale of 1 to 5. Overall, the pre- service teachers' self-efficacy is categorized well.

5. Conclusions

Research focuses on the pre-service science teachers' evaluation of the plastics island games and their motivation in implementing citizen inquiry. All in all, the results show that pre-service teachers' evaluation of the game is good. Their motivation to implement citizen inquiry mostly comes from intrinsic motivation. The mean intrinsic motivation score outnumbers the extrinsic motivation with 3.92 (S.D. = 0.57) and 3.52 (S.D. = 0.72), respectively, on a scale of 1 to 5. At the same time, pre-service teachers' self-efficacy shows good results, and the mean score surpasses three on a scale of 1 to 5. A digital game can be one of the alternative technologies to support citizen inquiry learning. A further suggestion is to implement the technology (digital game) for fostering pre-service teachers' skills in the teacher development program.

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Proposing the ARCS Model of Motivating Learning and Problem-based Learning in Teaching Image Processing

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Abstract: The success key of teaching in the undergraduate engineering courses is that the teacher plays an important role in motivated students in order to make students enjoyable the class. In this study proposed the learning framework design of integrated attention, relevance, confidence, and satisfaction (ARCS) model and problem-based learning (PBL) model for driving the activity during studying the image processing. MATLAB App Designer is used as a tool for coding and graphical user interface (GUI) in purpose to support students' motivation and enhance learning efficiency. At the end of the course, students will get the real-world issue then using their knowledge to solve the problem. The expected goal after students completes the subject which using this framework is that they will have a self-Confidence in using image processing skills in the real world.

Keywords: Image processing, problem-based learning, ARCS model, engineering education

1. Introduction

Image processing course is the importance subject of Mechatronics, Computer, and electronic engineering which improves students' science, technology, engineering, and mathematics (STEM), but students play less attention in this subject. One of the reasons is that the students cannot find the relationship between the content of image processing to the real life. Therefore, the motivation is the most significant to convince students to satisfy studying in class. This is the challenge for teacher to design the learning strategy.

Traditional methods of teaching such as face-to-face learning in the classroom are helpless students' attractive in studying in this generation. This is the time to find the way to help our students to be open-mind. Students' motivated in learning contexts is the importance choice to support students learning to get better efficiency study (Pintrich, 2003). Keller (1983) proposed the motivation model which becomes one of the famous motivation models known as ARCS model. This framework consists of four factors to guild for motivation, attention (A), relevance(R), confidence(C), and satisfaction(S).

ARCS model is the basic method to help students in motivation. In addition, Problem-based learning (PBL) supports students to be more self-assured. The objective of this work is to design the learning framework in image processing course for undergraduate engineering program. The expectancy outcomes are to enhance students' motivated and self-confidence. The ARCS model is addressed as the framework for designing the motivation activity before studying in the class. The PBL approach applied to drive the last activities.

2. Literature Review

The motivation has influence for motivating students to be more interest in the subject. It has many materials to supported students' learning motivation for instant, augmented reality (AR) on project- based learning (PjBL) for pre-service teachers' motivation (Chookaew, 2017).

ARCS model framework of motivation is the basic framework that educational concept is still use. Various research use motivation-based ARCS model to help students learning achieve in many area such as, Business, Technical, STEM, English second language, Social science, Professional and vocational, and multiple (Li, 2018). In STEM subject area, ARCS model has an influence for motivation. For example, C# programing language course for first year of university was used of integrated ARCS model of motivation and PBL in order to improve learning outcomes (Chang, 2018). Flipped classroom was applied to help students' motivated based ARCS model in physics course at the university (Asiksoy, 2016). Moreover, ARCS model use for evaluated the efficiency learning motivation in quantities and qualitative of Engineering Problem Solving and Computer Tools for freshmen engineering students (Huang, 2004).

3. Methodology

The image processing class in this purpose is using ARCS model to drive the activity for helping students' motivation before going to studying in classroom. During motivation, graphical user interface (GUI) is used as a tool to interact with students for getting some idea. Moreover, teacher helps students to get more intrinsic and extrinsic motivation in order to get better studying in the classroom. When students complete studying in all units, they have to present their knowledge using PBL. Students learn in teamwork beside skill. In addition, it helps students to be more comfortable or confident to use their skill after they finish this course.

3.1 Learning Framework

This study proposes the design learning framework of teaching image processing using ARCS motivation model and PBL to drive the activities. The designed learning framework shows in Figure 1. In this design, the framework starts with using the ARCS model for motivation before students' study in the detail of each chapter. The MATLAB app design is use as a tool for encourage students' motivation. Students play with GUI to test the algorithm. The benefit of using MATLAB app design is that students can interact with the interface. After students finish all units, students have assigned to work as team in PBL activity. In this activity, students use the knowledge and skill from the studying to solve the problem. The expectation of using this framework is that students gain encouragement and be open mind before they study with teacher. In addition, students show their creative thinking ability from study through PBL activity.

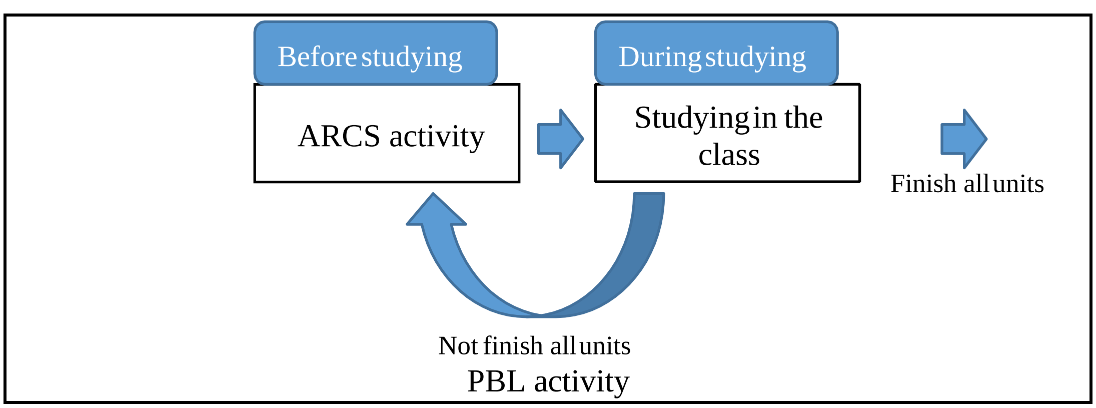


Figure 1. Learning activity framework

3.2 Learning Tool Design

MATLAB app design was used to create GUI. It uses a drag and drop for designing interface as shows in Figure 2. For image processing code, we can insert the code in the code view as in Figure 3. The benefit of using MATLAB app design for teacher is that it is easy to use for creating GUI with image processing. For students, the GUI helps to represent data information in graphic which is make sense to students to get the idea.

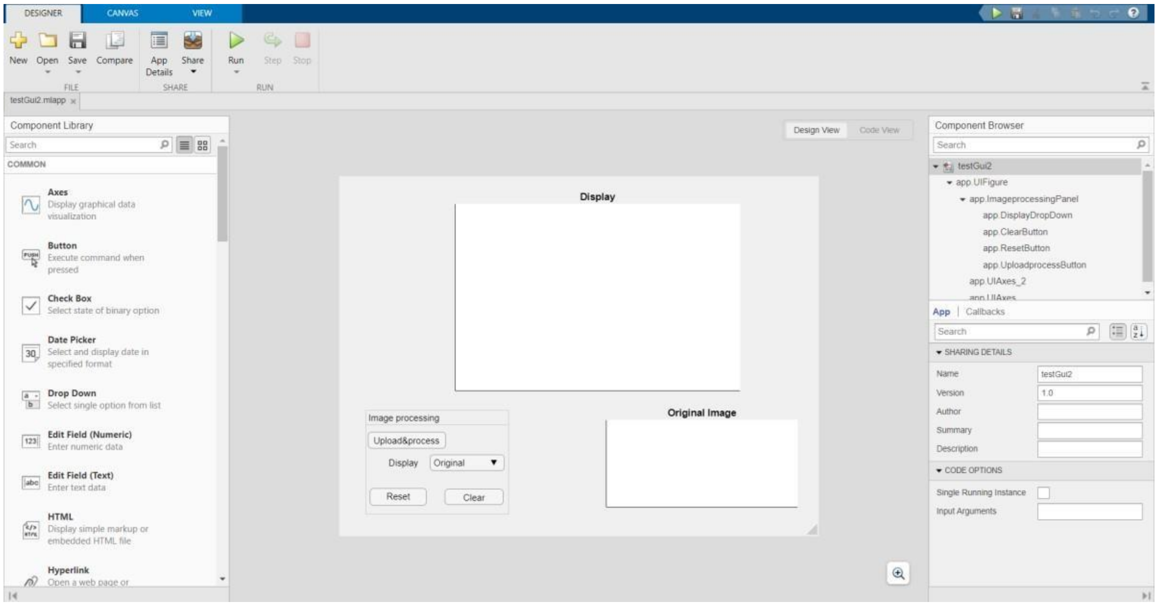


Figure 2. Design view

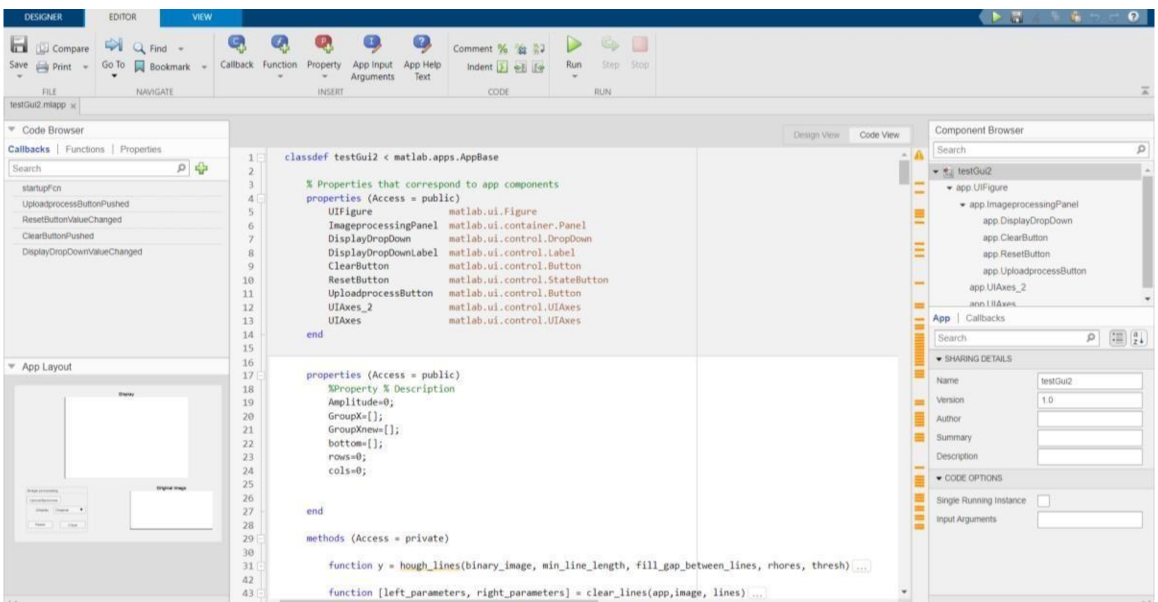


Figure 3. Code view

3.3 Design Learning Activities

The image processing course consist of the five main units which are techniques for image analysis, image transformation, image enhancement and restoration, object recognition, and applications in image processing. In this design, we start with the ARCS model of motivation using MATLAB app design for motivation before students' study in the detail of each chapter. The app design in each activity is programed by teacher. Students are only play with GUI to test the algorithm. The benefit of using MATLAB app design is that students can interact with the interface. Moreover, GUI play role with help students more attention and make sense to shows the relevance between the concept and the real world. In addition, the teacher needs to support the experience to help students to believe they can success to understand which make students more confident. The last lesson of doing motivation is to give some praise to students to make student feel satisfaction before going to studying in the detail of unit. The example of MATLAB app design in the topic of fundamental color model is show in Figure 4. In this unit, students learn how to convert image from one color model to other models such as RGB color model to grayscale model, RGB color model to Binary color model, and RGB color model to HSV color model. The example result of converted paddy field image is shown in Figure 5. After students finish all units, they have assigned to work as team in PBL activity. In this activity, students use the knowledge and skill from studying to solve the problem. • *ARCS Activity:* MATLAB app 5 units ○ Playing with GUI before study in class ○ Motivation students by teacher

- In class study for 5 unit ○ Studying in class with teacher ○ Doing the laboratory exercise
- *PBL Activity:* PBL (teamwork) ○ Brainstorm on their problem topic ○ Discussion with teacher
    - Analysis ○ Evaluation
    - Presentation on their topic

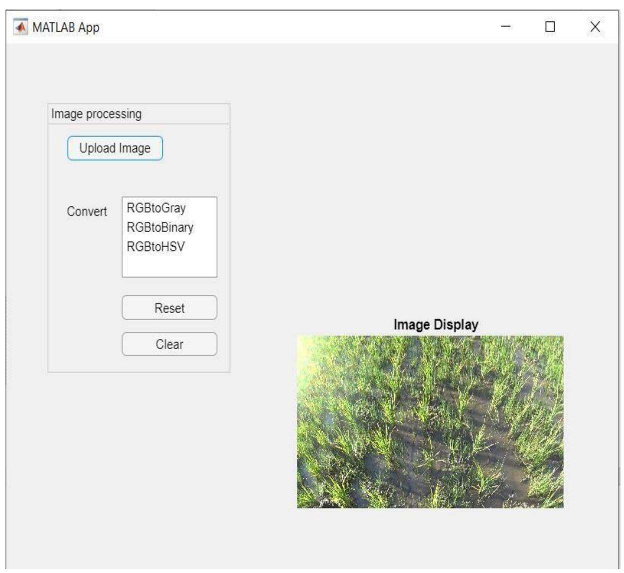
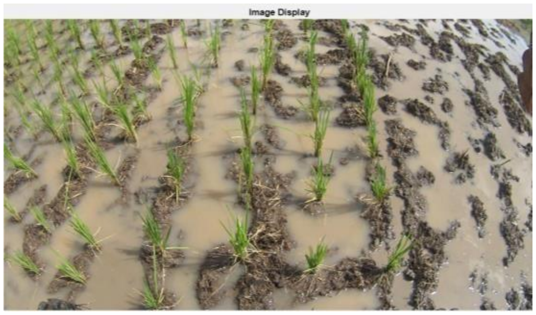


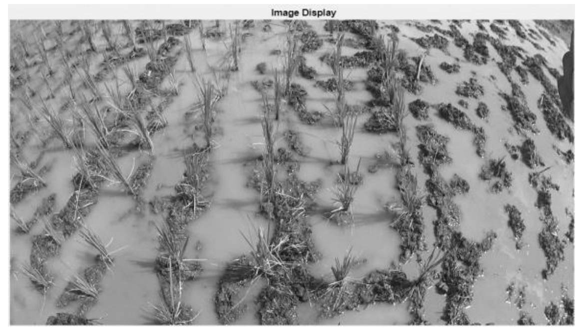
Figure 4. Fundamental color model GUI

The example of PBL of image processing course is shown in Figure 6 which is used for agricultural automobile robot application. The problem in this situation is how the robot travelling along the paddy field without damaging the crop. One solution is to use local localization by using image processing. The autonomous robot utilizes the vision system for travelling in the paddy field. Firstly, images need to pre-process. In this process, the image is cropped at the region of interest to reduce the size, then convert from RGB to grayscale image. After smoothing the grayscale image to reduce noise, the segmentation of image is applied. In this step, a binary image is created by using threshold methods such as adaptive, Otsu, and exceed green etc. The result of using exceed green is shown in Figure 6(a).

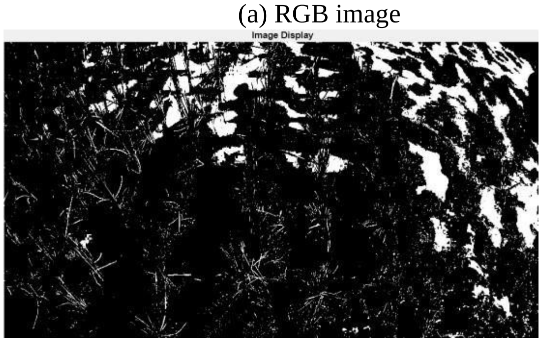
Several methods related to find the line guidance in the image such as Particle Component Analysis (PCA), Random sample consensus (RANSAC) and Hough transform can be implemented. GUI displays the resulting image with the estimated lines. The properties of line such as the position in image frame and the slope of each line are the output data of image processing and can be used further.



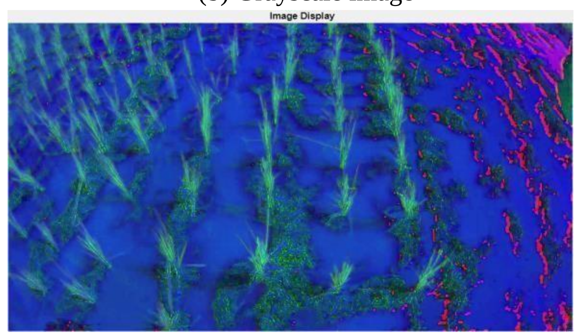
(a) RGB image



(b) Grayscale image

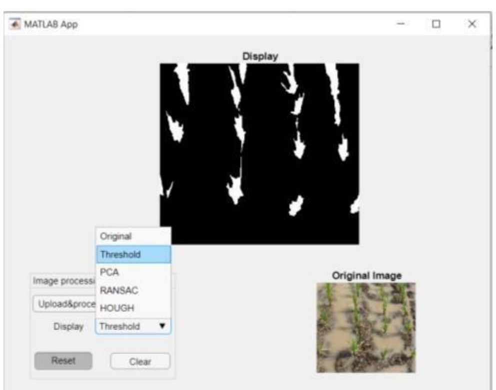


(c) Binary image

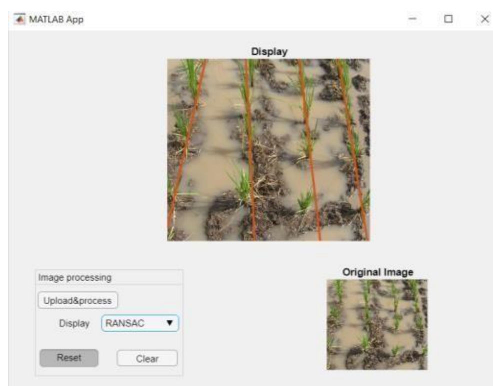


(d) HSV image

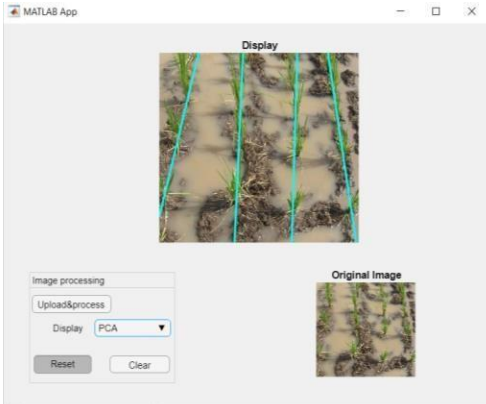
Figure 5. Example of convert color



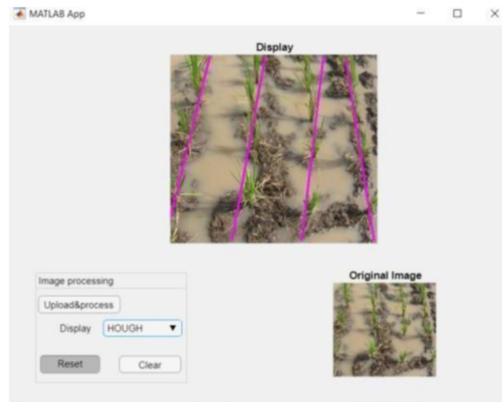
(a) Threshold result



(b) RANSAC result



(c) PCA result



(d) Hough transform result

Figure 6. PBL activities

4. Conclusion and Future Work

Traditional teaching in image processing is less attractive student to study in classroom. Most students are not aware of the importance in using image processing based on the basic concept. One of the reasons is that they cannot find the relevance in real life. In this work, we purposed the ARCS model and PBL technique to encourage students in learning image processing. We expect ARCS activity will help motivate students before they are joining in the class. Students play with GUI to see the result in real world that guarantee students have the idea what they going to study in the detail. After students complete with activities-based ARCS model, the students are helped to acquire attention, relevance, confidence, and satisfaction. Then students will be happy and open mind for learning new things with teacher in the classroom. Thus, the motivation is the major point to support teaching in image processing. After students complete studying all unit, they have to explore their skill in PBL activity. In this paper, we give the example to solve on navigation by using image processing based on crop rows. This task helps students to show their skill and support their successful learning in image processing. For the future work, this design framework will be applied to the image processing course in order to evaluate students' motivation in quantities and qualitative. Moreover, the result of using PBL will be evaluated in order to measure the students' creative thinking skill compared with the group of not using ARCS activity.

Acknowledgements

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Implementing STEM Project-based Learning and Scaffolding Strategy for Electrical Engineering Students in a Feedback Control Laboratory Course

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Abstract: The control system is the significant unit of study for the third-year Electrical Engineering. Mathematics, physical, digital signal, and programing are involved in the course. The challenging of teaching this course is the concept quite difficult to relate between the mathematical concept and the real applications. Therefore, in this research the control system laboratory course is provided the teaching approach using scaffolding and project-based learning (PjBL) to help guidance students step by step as a scaffold to enhance the students' learning experience than using the traditional teaching model. The learning approach of this model is to providing supports students' successful deep learning in feedback control system concepts and complete PjBL. Moreover, the students were encouraged with systemic thinking and engagement in class.

Keywords: feedback control laboratory, project-based learning, scaffold, engineering education

1. Introduction

The context of control systems based on science, technology, engineering, and mathematics (STEM). In recent, STEM frameworks are increasing involved in the engineering curriculum. The traditional teaching models do not provide a good solution of teaching in the engineering education because the students are only passive learning. Moreover, the students cannot engage concept of knowledge and the physical world applications. This is the challenge of teacher to solve the problem.

The PjBL is one of the types in problem-centered instructional approaches which student can be active learning. This approach is very useful in STEM education. PjBL help to increate inquiry learning, engagement, creativity, skill and critical thinking skill. In addition, it can help to improve a soft skill such as working as a team or collaboration.

Scaffold is a technical to help students to achieve learning or task when students cannot be able to complete it by themselves or struggle. The scaffolding guide base on individual students' skill. Students can get more support if students' have low level ability. On the other hand, the support could be decrease when students gain more ability to finish the task (Belland, 2017).

This aims of this research is to use the scaffolding techniques in Feedback Control Laboratory course in purpose to supports student able to do the PjBL, which helps students to deal with real life problem. For the scaffolding act like a guide tool to ensure that the students can cope with the complex solution. To use of scaffold for STEM PjBL is one of the keys to help students to be able to solve the problem and created the project with students' knowledge.

2. Literature Review

PjBL approach is normally use in teaching for engineering. Many researchers have investigated the benefit of PjBL approach. Andrade (2012) proposed the opinion of leaning in PjBL that the method can help student to understand mathematics, conceptual and more realistic way to cope with the problem as an engineering. In addition, PjBL was integrated to vocational teachers to persuade teacher to use information and communication technology to support their teaching (Chookaew, 2017). Moreover, the critical thinking, creativity, and transfer of learning skills are other three important parameters that need to improve in the student engineering. PjBL and Substitute, Combine, Adapt, Modify, Put to another use, Eliminate, and Reverse (SCAMPER) strategies was implemented in the computer science and the engineering project courses in purpose to improve critical thinking, creativity, and transfer of learning skills (Wu, 2020). PjBL have a big advantage not only for student engineering but also have a big challenge on some students because they cannot complete by themself. Vygotsky's proposed the idea zone of proximal development (ZPD) of children learning. The model consist of the child can do independently and the child cannot do without supporting. Therefore, to complete the project, each student needs the different supporting. Many researchers try to find the way to help student to success on learning using PjBL. One of the strategies that use to cope this problem is scaffold. Such as, a case study of students which difference backgrounds in Applied Mathematics, Civil Engineering, and Industrial & Engineering Management are doing PjBL together. The scaffolding techniques help them to achieve their project (MacLeod, 2020).

However, learning context of feedback control systems using PjBL is important for electrical engineering students. Students need to find the relevance between concept and real applications. Moreover, students need to practice in critical thinking skill and collaborator skill. Not all students can hand on the project by themselves, sometimes they need the supporting from the expert person. Teaching approach by PjBL with scaffold can help increase student to success on learning because the scaffold technic help to find the suitable way for each student problem.

3. Methodology

The implementation on scaffolding in PjBL is used during feedback control laboratory course. The experiment was set up for third year of Electrical engineering program in Sirindhorn International Institute of Technology, Thammasat University (SIIT). Firstly, the students who pass the Feedback Control Theory course, conducts the laboratory for eight topics: Modeling and Simulation in MATLAB/Simulink, SIMULINK: Proportional plus Integral plus Derivative Controller, Compensator Design, Electronic PID controller, Introduction to Sensors and Actuators, Introduction to PLC, Advanced PLC programming, and PID Controller for Servo Systems. These topics contain the computer-based simulation for computer-aid design purpose, and the hand-on experiment for relevant with the real applications. After they finished all topic, they are encouraged to choose one out of three PjBL topics and worked in small team. Scaffolding was set as an instructional strategy for guideline students in these activities. During they did the experiment on PjBL, teacher assistants (TA) guided the students for helping them to reach the goal. At the end of the course, students had to present and demonstrate the students' competition PjBL and discussed with other groups and TA.

3.1 Learning activities framework

In this research, we focused on implementing scaffolding strategy to supported student learning in Feedback Control laboratory course. In each students' group, the instructions of supporting are difference between students' group. It depended on current students' ability. The expected goal of using scaffold is to support students to generate students' motivation, creativity, and skill to complete PjBL activities.

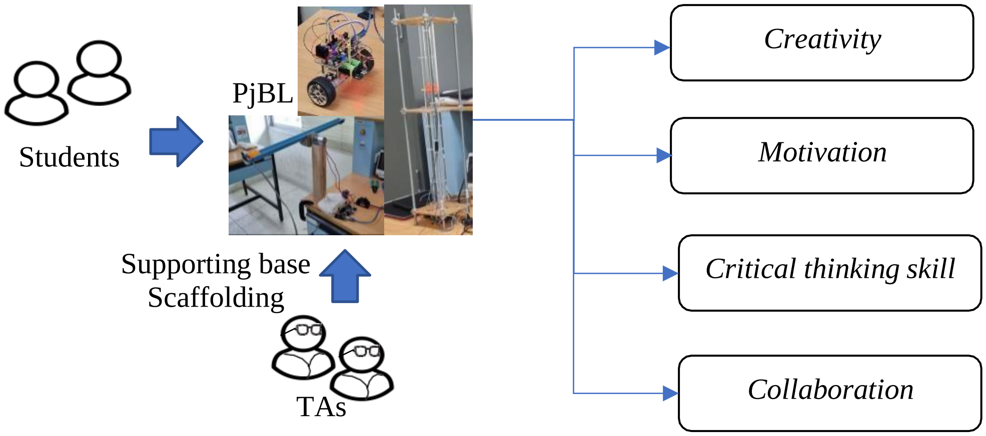
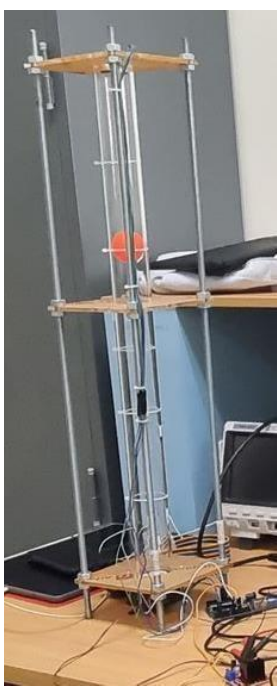


Figure 1. PjBL with scaffolding activities framework

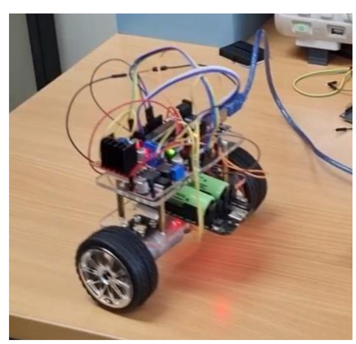
3.2 Learning tools design

In this work, the PjBL was created in three topics: ball levitation, ball and beam, and two-wheels balancing robot as shown in Figure 2 for addressing the different control problems. Technically, the objective of ball levitation is to stabilize the height of ball in the transparent tube by adjusting the speed of fan duct. The challenge of control action is to deal with nonlinear term in gravity force acting to the ball and air turbulence inside the tube. The objective of ball and beam is to maintain the ball position by adjusting the slope of beam. Two-wheels balancing robot, well-known unstable system is to stabilize the body of robot the in upright position. Arduino Uno board which is low-cost and easy for self-learning is utilized as the main controller for receiving all sensors information, calculated the control action and sending the pulse width modulation (PWM) command to the DC motors.

The students are assigned as 2-3 members per group for working as a team. Each group selected their own topics as they prefer. After topic selection, the parts such as acrylic bodies, DC motor and necessary electronic components were distributed to each team.



(b) Ball and beam system



(a) Ball levitation system

(c) Two-wheels balancing robot

Figure 2. PjBL topics

3.3 Learning activities design

Before starting the project based, the students require to achieve feedback control theory course in the period semester. Then conduct the traditional feedback control laboratory for 8 weeks. Three topics are computer simulation to model, design and simulation and evaluation the time-domain response. The rest topics are experimental laboratories which is relevant between the control theory and actual hardware, as shown Figure 3. The instructor provides the material and shortly briefs the context of each module to review students' basic knowledge. After the students conducted the experiment following the instruction, they need to summarize what they had learnt. The expected outcomes of this process are to review the basic knowledge of feedback control, be familiar with the software and hardware equipment, and the getting the idea of coding.

Activity 2 had been served after students' complete activity 1. In this period, students are assigned as group of 2-3 persons. Each group selects only one topic from three hand-on PjBL topics as mentioned in previous section. The process is involved in learning, planning, constructing, discussion, testing, evaluation, presentation, and demonstration. In addition, students can learn a teamwork skill.

In this process, based on the scaffold strategy, the supported learning can be obtained both from TAs and team members. For TAs, they are encouraged to support students in each team to gain more complex skill which students cannot learn by themselves to complete the PjBL. Team members can advise friends among groups immediately when someone in the team have problem until the skill level of all members are the same. The following is the activities that we are mentioned above.

- *Activity 1:* learning 8 modules and conducting the experiment in a usual class
- *Activity 2:* PjBL (hand-on) ○ Learning / brainstorming ideas/ research on their topic ○ Planning/ designing the schedule of project ○ Constructing the hardware tool
    - Discussion with TA ○ Testing/ analyzing ○ Evaluation
    - Presentation and demonstration

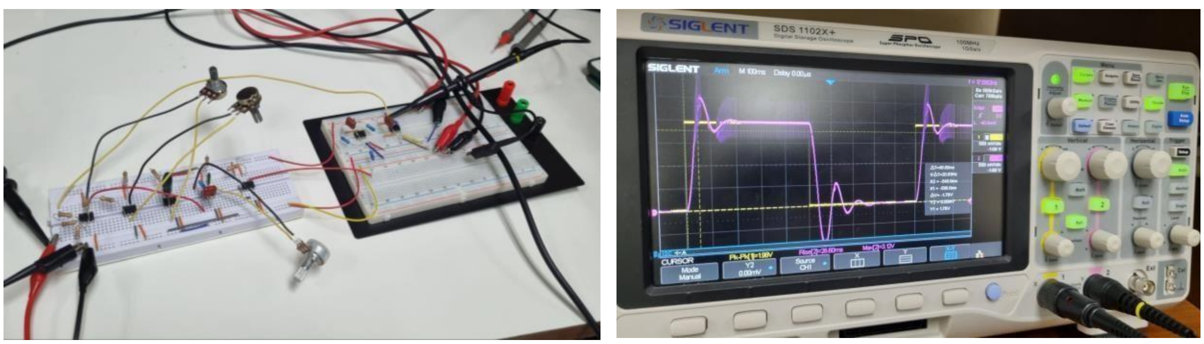


Figure 3. Example of experiment in activity 1 on the topic of electronic PID controller

4. Results

To evaluate students' learning using PjBL, we asked students for survey the questionnaires based on outcome of students learning. In addition, to evaluate students' performance, TAs give the score for each group which are depended on the performance.

The survey has been collected data in both qualitative and quantitative. The survey has seven questions which the result shows in Table 1. The result shows that PjBL are strongly help support students in creativity, motivation, critical thinking skill, and teamwork. The collaboration is the best impact on doing PjBL followed by motivation and critical thinking respectively. As students' viewpoint, the Pros and Cons of online feedbacks are represented in Table 2. Some students are the satisfying with our implement approach. They feel they gained more knowledge, and motivation from PjBL. Moreover, TAs and senior student can support to students to do the project based on the scaffolding strategy. On the other hand, some dissatisfaction feedback is also shown for example, they cannot crop with the hardware problem and time limit. This kind of feedback helps the instructor and TAs for improving the PjBL in the feedback control course in the next year.

Table 1. *Analytical results of student survey.*

questionnaires ***Experiment***	***5***	***4***	***3***	***2***	***1***	***mean***	***SD***
PjBL supports students to gain their skills in using handyman tools.	23	6	5	1	0	4.22	0.85
PjBL supports students to gain more encouraged and motivated.	26	6	2	1	0	4.38	0.73
PjBL supports students to gain experiment on analysis and evaluate problem.	22	7	5	1	0	4.19	0.85
PjBL supports students to gain relevance between theory and real-world applications.	20	10	4	1	0	4.16	0.81
PjBL supports students to gain positive attitude in learning	23	6	4	2	0	4.19	0.92
PjBL supports students to gain applying creatively with other relate applications	24	8	2	1	0	4.32	0.74
PjBL supports students to gain skill in teamwork.	26	7	2	0	0	4.43	0.58

Where 5, 4, 3, 2, 1 mean strongly agree, agree, fair, degree, and strongly disagree respectively.

Table 2. *Student' point of view*

Students' point of view
Thank you, teacher I have gained a lot of knowledge. It's like being an engineer. It's really fun to do, write the code, assemble the machine, connect the wires, and most importantly solve the problem. It appreciates to know how well we can do it. Thank you very much. Love it.
The course is well organized and TA's are so supporting too.

This is what I am waiting for in Electrical engineer studies. Hand-on project is the best way to implement my knowledge, it is very fun. Thank you so much!
I take much time for this project, and I have learned overalls about technical skill from project. Thank you, teacher, TA and brother Phatam.
The electronics which teacher gave are sometime not efficiency to the project itself.
From our group viewpoint: First, the 12VDC motor might be too heavy for typical battery supply on that size. Second, the ADXL345 measurable sensor might be suitable in theory (alignment of sensor), but the spike (noise) was hard to be compensated in higher acceleration.
Need more time for doing the final project.
Because the score criteria is the same for every project, the difficulty of every project should be roughly the same.

5. Conclusion

In this work, we implemented the PjBL with scaffolding strategy to help students achieve for leaning in Feedback Control Laboratory Course. Student survey shows that students agree on using PjBL can gain in their outcome on motivation, creativity, critical thinking skill, and collaboration. And with the scaffolding strategy that TAs use for guideline the need of help of student in PjBL can help support students to complete their project.

Acknowledgements

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The ABC Workbook: Adapting Online Judge Systems for Introductory Programming Classes

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Abstract: The online judge is an established method of automatic assessment for programming tasks. Recognizing the relative lack of problems and resources for introductory- level programming classes, we present the ABC Workbook project, a workbook containing a comparatively large selection of basic programming exercises, accompanied by an application written to check the exercises in the workbook. The contents of the workbook, an overview of the app, and strategies for integration in a class are discussed. The accessibility of the app for use in remote and developing areas is emphasized. The project is expected to improve introductory-level programming instruction, by facilitating immediate feedback and providing access to a bank of curated problems. Future work involves application in classrooms, as well as implementation of problem creation features.

Keywords: Computer science education, automated assessment, textbooks, introductory programming.

1. Introduction

Introductory programming classes rely on the students' ability to receive feedback for their work. These classes have two primary learning objectives: programming knowledge, via the syntax and semantics of the course's chosen language; and problem-solving strategies (Malik and Coldwell- Neilson 2017). These objectives are reinforced by assigning practice exercises to students, usually which require them to write a simple program which can perform a desired task.

However, the effectiveness of these exercises relies on the ability of an external entity (e.g., a teacher, a software program) to give feedback to the students. A novice programmer cannot just self-evaluate that their code "seems correct." Practice in algorithmic thinking requires stricter supervision because correctness and efficiency may not be apparent to a beginner. For example, the student might be overlooking an edge case, or their logic may contain a faulty argument that had gone unnoticed.

As a resource for such exercises, traditional textbooks are lacking in two regards. First, traditional textbooks focus heavily on content delivery of programming knowledge, and not as much on exercises and problem-solving skills (Demilie 2020). Second, even if a traditional textbook had many exercises, it still could not be effectively self-studied, as an instructor is required in order to give feedback. Even with an instructor, the workload of checking the code submissions of each student for each exercise scales poorly to upwards of hundreds of students, which may lead to the instructor not assigning too many programming exercises in their classes, which is also not ideal.

With the shift to e-learning, there is a clear need for a resource which is capable of giving automated feedback to programming students. Fortunately, such a system already exists and has been used by the competitive programming community for more than two decades now: the online judge. Some well-known examples of online judges are: Codeforces, UVa Online Judge[1], and CSES.

[1] Since the passing of the site's maintainer, Miguel Revilla, the site is now simply called Online Judge, as it is no longer associated with the University of Valladolid.

1.1 The Online Judge

The online judge is an automated assessment tool. They have been successfully used as an effective assessment tool for data structures and algorithms courses (Enstrom et al. 2011; Garcia-Mateos and Fernandez-Aleman 2009). CSES is itself used in facilitating an algorithmic programming course in the University of Helsinki (Laaksonen and Talvitie 2020).

Each task on an online judge typically involves the creation of a program whose specifics are laid out in the scenario given in a problem statement. As an example, in Figure 1, we show the problem "Coin Piles" from the online judge CSES. The desired behavior of the program is stated using generic parameters. In Figure 1, we see that the coin piles' sizes are given by variables a and b, and the number of test cases is also some variable t. The contestant's program is given, as input, particular values of e.g. t and each a and b, representing some concrete instance of the input parameters. The program should then output the correct answer for this instance of the problem.

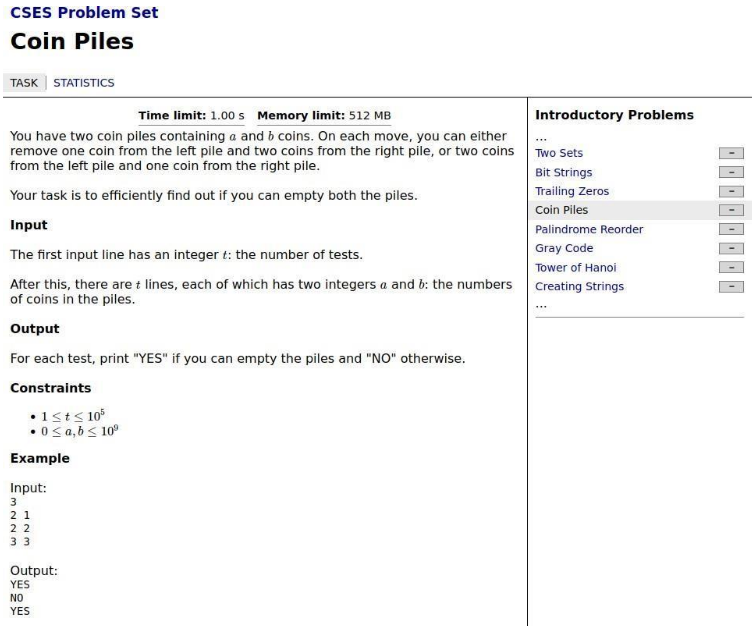


Figure 1. Sample task "Coin Piles" from the online judge CSES

The problem author prepares several test files. To test the correctness of the submitted code, it is run with each of these test files as input, and a judge program automatically checks whether the contestant's program produces the correct output for each one. The author writes a model solution to the problem, and the judge checks that the output of the submission exactly matches the output of the model solution. For tasks with multiple possible answers, the problem author may instead write a custom checker program which verifies the correctness of the contestant's output. A time limit and memory limit are also given in the problem statement, and if a submission consumes more time or resources than is allotted to them, it is also marked incorrect.

Constraints are given which limit the kinds of values which may appear in the input. Strict formats on input and output are imposed so that the feedback process can be automated by the online judge. Assuming that the problem author's test data is robust in handling all the different cases and detecting incorrect solutions, a student is able to automatically receive feedback on the correctness of the programs they write through an online judge.

1.2 Issues with Online Judges

There are a handful of factors that limit the accessibility of existing online judges for use in introductory programming classes. First, problems in existing online judges were not designed to be exercises for introductory programming classes. Sites like Codeforces and UVa are archives of ACM ICPC-style contest problems, and so even their "easy" problems may require finding mathematical insights that are outside the scope of the class or require concepts that would appear in a data structures and algorithms course, not in an introductory programming course.

Second, it is not easy for an instructor to create and upload their own problems to many online judges if it is possible at all. There is a nontrivial technical barrier in authoring a problem using Codeforces' problem-creation platform, and in giving students access to these custom problems. Administrator access is required to upload problems to UVa and CSES.

Third, all of these online judges are dependent on the student having a stable and persistent internet connection. This makes these platforms inaccessible to students in remote or developing areas without a stable internet connection.

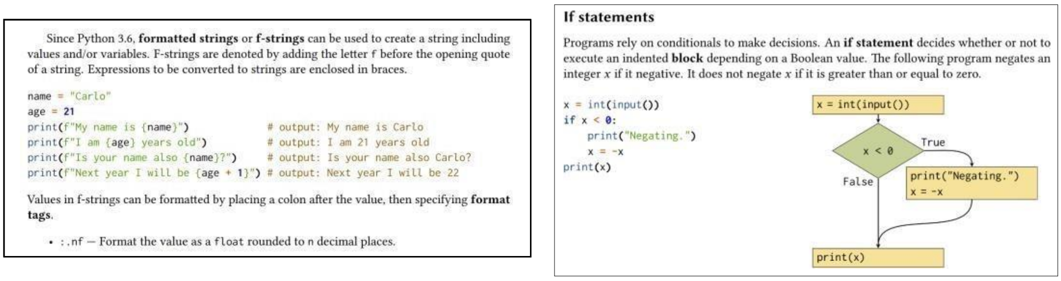
2. The ABC Workbook Project

The ABC Workbook project is intended to address the issues we have identified in applying online judges to an introductory Python programming class. The project is comprised of two parts: the *ABC Workbook* and *AutoJudge++*.

2.1 The ABC Workbook

The ABC Workbook is a problem bank for introductory Python programming, intended to supplement an introductory programming or computer science course by providing a curated collection of exercises. It is planned to contain exercises under the following topic areas: variables, data types, input and output, conditionals, loops and nesting, built-in data structures, functions, recursion, classes, and basic design patterns. These topic areas align with most of the topics in the Software Development Fundamentals (SDF) knowledge area in the ACM/IEEE curriculum guidelines for computer science, which characterize many introductory computer science sequences (ACM Computing Curricula Task Force 2013). As a result, the workbook does not assume any prior programming knowledge.

Each section of the workbook begins with a summary of Python syntax and constructs, accompanied with examples (Figure 2). This discussion is largely adapted from the official Python tutorials and language specification but with additional examples used to illustrate common usage patterns of programming constructs. The discussion is short, as most of the book's content is deferred to the exercises.



Since Python 3.6, **formatted strings** or **f-strings** can be used to create a string including values and/or variables. F-strings are denoted by adding the letter f before the opening quote of a string. Expressions to be converted to strings are enclosed in braces.

```
name = "Carlo"
age = 21
print(f"My name is {name}")             # output: My name is Carlo
print(f"I am {age} years old")          # output: I am 21 years old
print(f"Is your name also {name}?")     # output: Is your name also Carlo?
print(f"Next year I will be {age + 1}") # output: Next year I will be 22
```

Values in f-strings can be formatted by placing a colon after the value, then specifying **format tags**.

- :.nf – Format the value as a float rounded to n decimal places.

If statements

Programs rely on conditionals to make decisions. An **if statement** decides whether or not to execute an indented **block** depending on a Boolean value. The following program negates an integer *x* if it negative. It does not negate *x* if it is greater than or equal to zero.

```
x = int(input())
if x < 0:
    print("Negating.")
    x = -x
print(x)
```


Figure 2. Samples from the explanatory portions of the ABC Workbook.

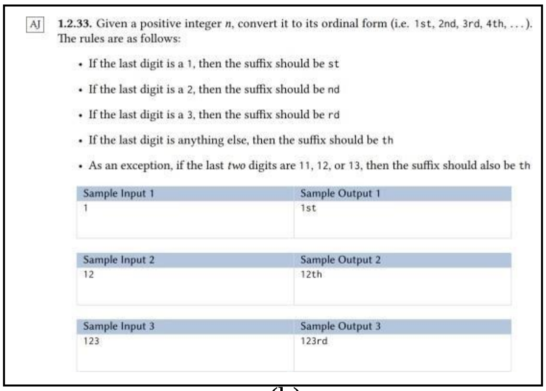
The discussion is followed by a collection of practice exercises. While a handful of the exercises are conceptual (Figure 3a), majority of the exercises are programming tasks, formatted similarly to those found on online judges (Figure 3b). Each exercise is written so that answers may be easily checked by the reader, either through an answer key, or using the accompanying AutoJudge++ application. This ensures that the workbook is suitable for self-study and remote use.

Compared to a number of introductory programming textbooks, the ABC Workbook contains a large quantity of problems. The book contains over 80 problems devoted to the use of basic data types, variables, and conditionals, while over 140 problems are devoted to iteration and lists. The full book is estimated to have at least 500 exercises. Table 1 provides a comparison with various introductory programming books.

Table 1. *Approximate Number of Exercises of Various Introductory Programming Books*

Book	Exercises (approximate)
Think Python, 2nd Edition (Downey 2016)	70
Introduction to Programming in Python (Sedgewick et al. 2015)	160
Python Programming: An Introduction to Computer Science, 3rd Edition (Zelle 2017).	180
C How to Program, 8th Edition (P. J. Deitel and H. M. Deitel 2016)	200
Big Java: Early Objects, 7th Edition	250

While the volume of exercises in the ABC Workbook may seem large in comparison, this is not unusual compared to many online judges. CSES has over 200 problems and is planned to contain 1000 problems (Laaksonen and Talvitie 2020). The ABC Workbook is comparable to a typical precalculus or calculus textbook, which often contain a similarly large number of basic exercises.



(a) (b)

Figure 3. Sample exerci ses from the ABC Workbook

2.2 AutoJudge++

Accompanying the ABC Workbook is a desktop application, AutoJudge++. Like an online judge, it allows for the automated checking of programs. The application is preloaded with most of the programming problems listed in the ABC Workbook, allowing those using the workbook to check their answers using the application. Unlike online judges, AutoJudge++ is built to function completely offline, running on the user's computer instead of an online judge server. This allows those without a stable persistent internet connection to use the app unimpeded.

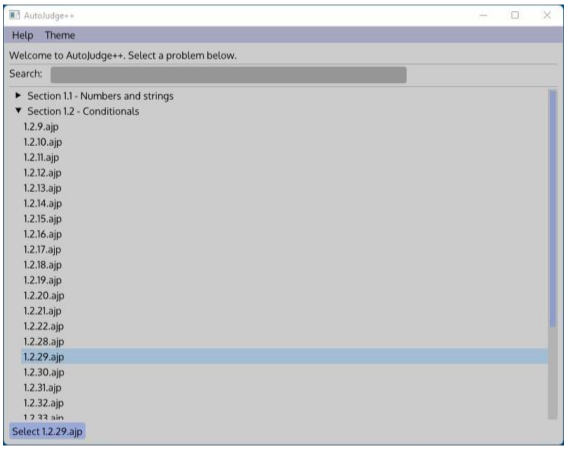


Figure 4. The problem selection menu of AutoJudge++

Upon loading the application, the user is presented with a list of problems, corresponding to marked problems in the ABC Workbook (Figure 4). Selecting a problem allows the user to then add Python file submissions. Students using the app can add a Python file containing their solutions, while teachers using the app can add a directory of Python files.

Each problem in AutoJudge++ is set up with a number of test files, covering a variety of possible inputs and edge cases depending on the problem. The app can then run the Python submissions on each test input, and automatically check if the output of the submission exactly matches the expected output. These results are summarized in a visual display (Figure 5). The user can inspect individual test cases to view the execution time, the input for the test case, the expected output, and the submission's output. Teachers using the app may also export a CSV summary of the verdicts for all submissions to a problem, which they can then incorporate into their own workflow for checking assessments.

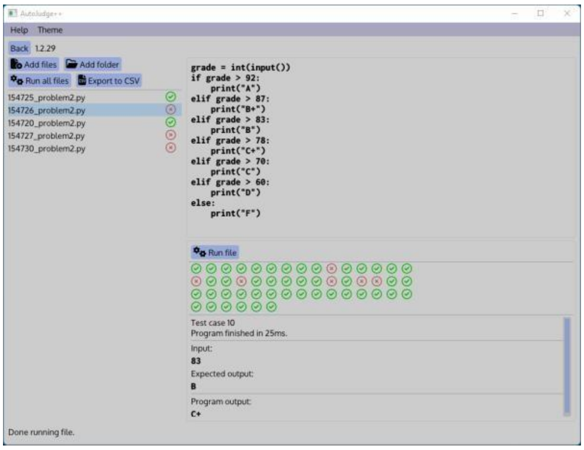


Figure 5. A submission for a problem, checked using AutoJudge++. The panel on the left shows all submissions. The panel at the bottom displays details for each test case for the current submission.

2.3 Integration and use

As the ABC Workbook project is a resource which simply contains a problem bank and automatic assessment tool, without any online dependence or defined submission workflow, it can be readily adapted for use in existing assessment workflows. It is recommended to combine both automated and manual assessment systems, with the automatic system providing ease-of-use and efficiency to the assessment process (Ihantola et al. 2010). We present several ideas adapted from existing literature here.

The AutoJudge++ application, like online judge systems used in education today, may be used with *test-driven education* (Enstrom et al. 2011). Teachers assigning programming tasks can ask their students to have their solutions checked by AutoJudge++ before presenting their solutions to the teacher. In this approach, students are allowed to have their program checked by the app any number of times, with the app serving as an adversary. This form of feedback encourages students to develop their programs based on concrete tests. When students present their program to the teacher, the teacher can focus on higher levels of assessment, by asking students to explain their understanding of their code, as well how they addressed issues during program development.

The test-driven education approach lends itself well to approaches such as *pair programming* (Waite and Sentence 2021). In pair programming, two people work simultaneously on a single project, with one person actively using the computer, while the other reviews the work done by their collaborator and offers suggestions. As students are able receive immediate, independent feedback through the AutoJudge++ app, students are constantly confronted with problems mid-development as they try to pass all test cases, sparking discussion and activity among the students. This is an integral part of the teamwork involved in the competitive programming environments, and this can be adapted for use in introductory programming education.

As we have established that existing introductory textbook contain relatively few programming exercises, the ABC Workbook project may be used as a problem bank for use in both assignments and exams, with the AutoJudge++ app serving to manage the workload of assessing many submissions for many exercises. Students may also use it as a self-study resource, due to the feedback provided by the project and the lack of dependence on online connectivity. The ABC Workbook may be distributed as a PDF file, while the AutoJudge++ app may be distributed as a zip file with no installation required.

3. Conclusion and Recommendations

In this paper, we presented the ABC Workbook project, a workbook and companion app for introductory Python programming. We demonstrated how these online judges can be adapted for an introductory resource. Through a brief survey of textbooks, we also established the need for larger volumes of exercises, to give students more opportunities to learn by practicing programming directly. Lastly, we presented methods by which these resources may be integrated in the classroom. We hope that this paper inspires related resource creation for introductory programming classes and furthers interest in designing accessible automatic assessment methods for programming assignments.

The ABC Workbook project is currently still under development. We are currently designing additional features for the AutoJudge++ application to facilitate easier *problem creation*. The goal is to allow teachers to easily create problems which can be checked by AutoJudge++, even without prior contest problem-setting experience. Further development can also focus on the security of the application, to ensure submissions cannot maliciously affect the host computer (Ihantola et al. 2010). Further work on this project may also involve a detailed examination of exercises in recent introductory textbooks and workbooks, as well as an investigation into the effectiveness of applying the ABC Workbook project in the classroom.

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Developing Autonomous Mobile Robot Navigation using Machine Vision System as a Learning Tool in Engineering Education

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Abstract: Teaching in Engineering program is a big challenge for future teacher because traditional teaching such as talk, and chalk does not suitable for new generation of engineering students. A good design course will integrate STEM teaching model to drive activities. In addition, teacher need to be focus on following the learning outcomes of the course. Therefore, the developing the tool for support learning must answer all learning outcomes. In this study realize the development a tool for teaching in robotic course base on learning outcomes. The key to this paper is to develop the autonomous mobile robot navigation using machine vision as a tool for using STEM teaching model in this course.

Keywords: robotic course, learning outcome, mobile robot, engineering education

1. Introduction and Literature Review

Nowadays, Generation students have been changed from Millennials (Generation Y) to Generation Z students. There have share some behavior, but there still have many huge different characteristics. The higher education institutions are still using the previous design environments which are helpless the new Generation students' interest in learning. Thus, the time to prepare for changing a design environment for suitable with Generation Z students. One of the topics is that Generation Z students prefer to learn the various applications more than only practical example (Seemiller & Grace, 2017).

Mobile robotic can use in wildly age from child to higher education. For children, they can learn concept of basic physic and technology such as using LEGO©. For high school student, mobile robot can use for teaching a basic programing and basic workshop course. For undergraduate students, they can learn more complex topics such as control system and robot kinematic through mobile robots (Gacovski, 2011). In recent year, many research works proposed several mobile robot platforms for teaching the basic concept in Engineering course. For example, wheeled mobile robot was conduct for laboratory in Master program (Fabregas et al., 2016). Some researcher using the type of mobile robot that use in agricultural application for teaching robotic and navigation content (Bautista, & Wane2018). Moreover, the researcher applied hands-on activities-based STEM methods though the mobile robots and a WEB-responsive software to teaching basic programing (Bacca-Cortes et al., 2017).

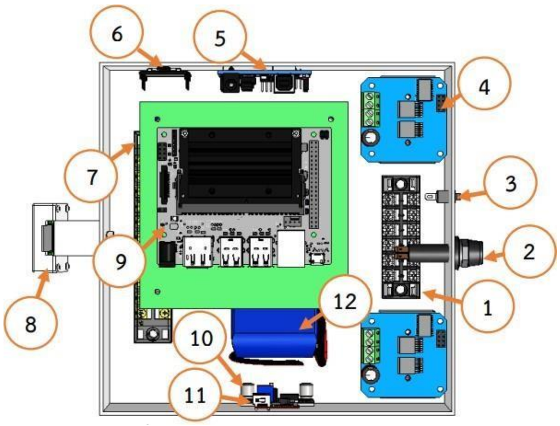
In recent years, new technology called machine vision plays importance role in automation system as a sensor. Machine vision system are helping to develop robotic applications in the section of industrial, household and agriculture. For instance, collaborative robotics for packaging utilizes machine vision to detect object and determine pose of the object, then applying a pick and place robot (Martinez-Franco & Alvarez, 2021). The example of using in agricultural application, the robotic mower avoid obstacle by using machine vision system (Inoue et al, 2019).

In this study, as the robotic with machine vision technology have wildly used in many applications, thus we realize on how to support student learning in robotic with machine vision concept. The main contribution is to develop the autonomous mobile robot navigation using machine vision as an interactive teaching tool for Generation Z students. The pedagogy is using hands-on activities to drive the learning activity based on STEM education. The development of autonomous mobile robot that use in the robotics course can be applied in various scenery such as agriculture, industrial, and household. Thus, students get a chance to create the solution to solve the various problems in the real world via the mobile robot.

2. Development of Autonomous Mobile Robot with Machine Vision

The development of autonomous mobile robot with machine vision was design to use in learning robotic course in purpose to support learning outcomes of the robotic course. Both mechanical and electrical components of robot are described in Figure 1 which consist of:

Number 1 and 7: Screw terminals
Number 2: Fuse
Number 3: Power switch
Number 4: DC motor driver
Number 5: Arduino Uno board
Number 6: ESP32 board
Number 8: CSI camera
Number 9: Jetson Nano
Number 10, *11*: DC voltage regulator
Number 12: Li-po battery
Number 13: Road wheel
Number 14: Track
Number 15: Idler wheel
Number 16: DC Motor
Number 17: Encoder



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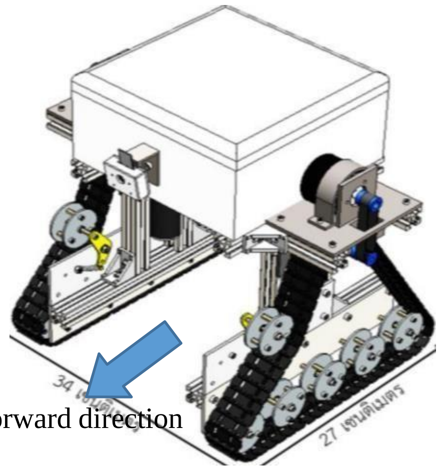

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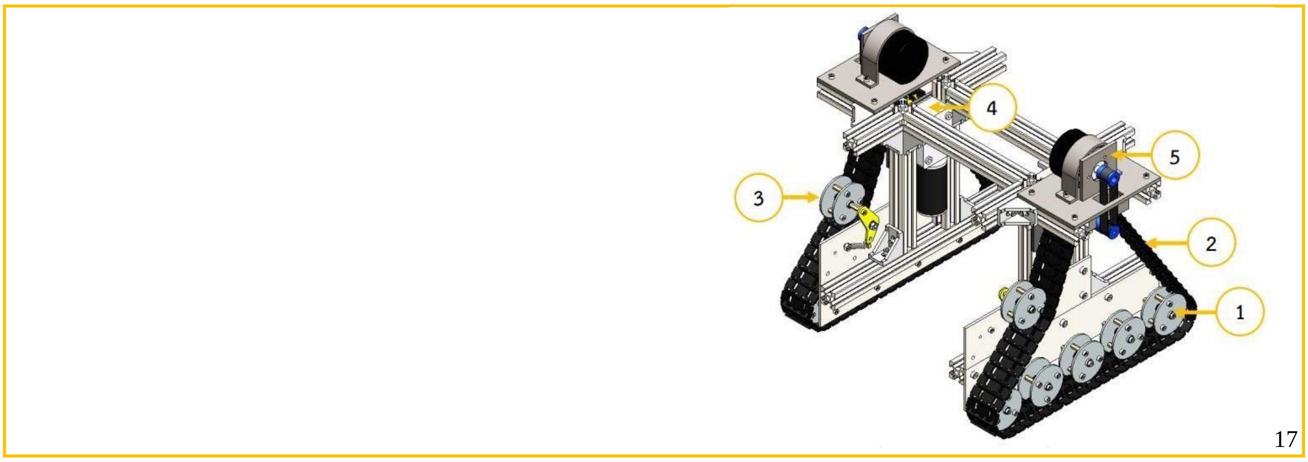
14

13

Electrical components



(a) Robot platform (b) Mechanical components

Figure 1. Components of robot

The diagram of system architecture is shown in Figure 2. Jetson Nano is utilized as a minicomputer for handling a machine vision and the robot control. The operator can edit a high-level programming or manually control the robot via WIFI. For low-level programming, Arduino Uno is used for acquiring the signals of two encoders, then computing the speed of the frame's robot based on two-wheeled differential robot's kinematics. ESP32 is implemented for providing the pulse width modulation (PWM) command based-on Fuzzy algorithm, also send the performance of speed control.

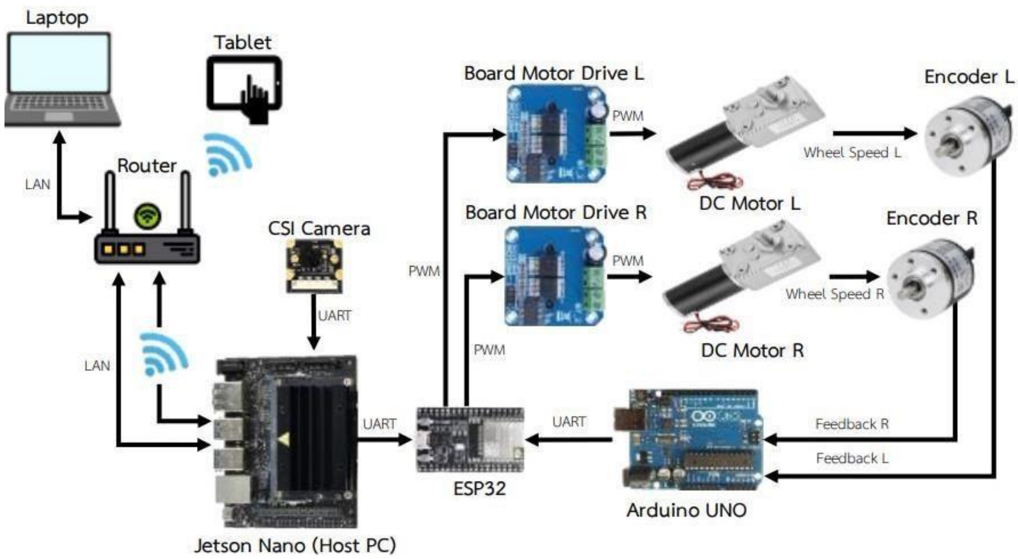


Figure 2. System architecture of robot

3. Conceptual framework

In this section provide into two subsections. First section presents an expected learning outcomes of the robotic course to train undergraduate engineering students. Second section describes the content of using autonomous mobile robot as a tool for teaching in robotic course.

3.1 Learning Outcomes

Learning outcomes define like guidance tools for guiding teachers' direction to support students to be able to achieve at the end of the program (Mahajan & Singh, 2017). Normally, the design of course learning outcomes are based on Bloom's Taxonomy. In this study, the autonomous mobile robot was developed as a tool for learning in robotic course to encourage students to achieve the goal of robotic course. At the end of this course, students need to be able to design the Mechanical and Electrical systems, analyze the kinematic of the robot, create programs for a control system, and apply machine vision to robot guidance. The learning outcomes of this course shows in Figure 3.

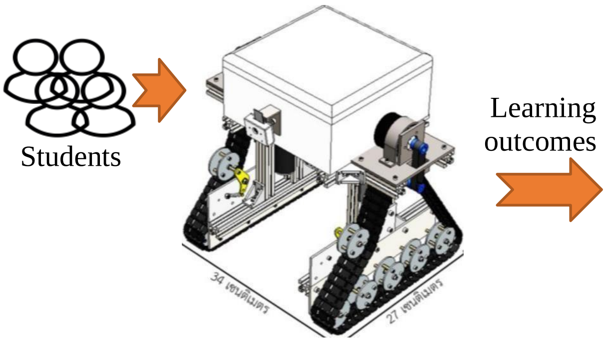


Figure 3. Course learning outcomes

3.2 Course learning activities

The content of this course based on the course learning outcomes has four main topics which the student be able

- Design a mobile robot in mechanical and electrical systems • Analyze the kinematic of the robot.
- Control the motion of robot by programming
- Apply the machine vision for robot guidance

The first topic states that the learner is able to design a mobile robot in term of mechanical and electrical systems. For example, the content gives students ability to select the suitable DC motor with the physic law. The maximum velocity of robot is pre-defined then the required angular velocity is obtained by (1), where ω is the required angular velocity, r is the driven wheel radius and v is the linear velocity of robot.

$$v = \omega r \tag{1}$$

As shown in Figure 4, the traction force at the robot track (F) must be equal to the friction force (F_f) so that the robot can move forward without slip. The friction force between the track wheel and ground is expressed in (1) by considering the coefficient of friction (μ), normal force acting to the ground (F_n). Then the minimum required power of DC motor can be calculated by (3)

$$F_f = \mu F_n \tag{2}$$

$$P = F_f v \tag{3}$$

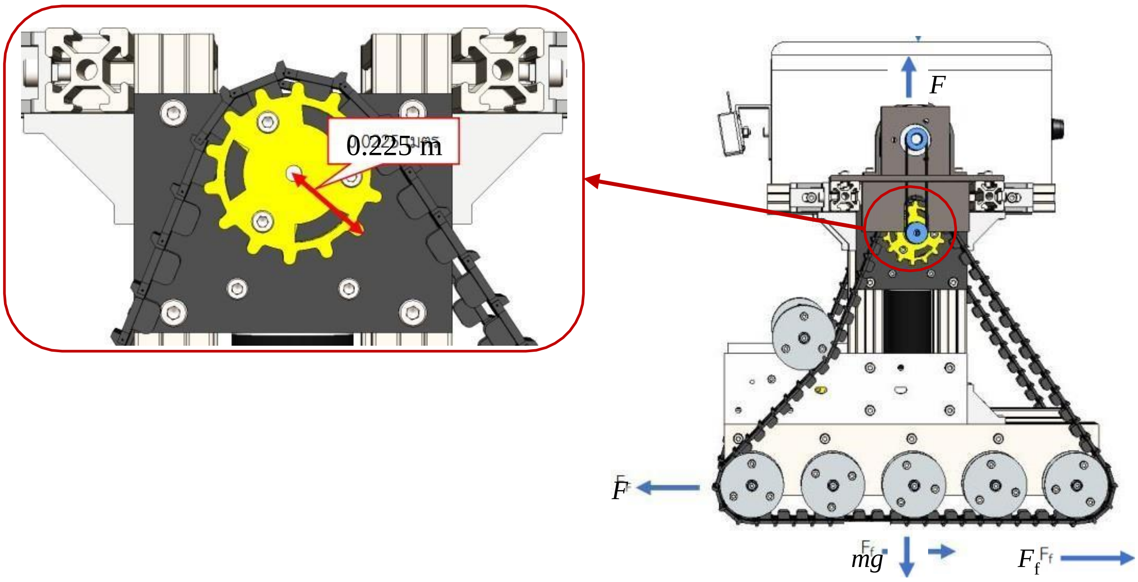


Figure 4. Calculation of required power

Next content, the kinematics of the robot that relates the motion of robot's frame to the wheels' velocity. In this work, the differential wheel robot is introduced to the students. The position described in the 2-D Cartesian coordinate and orientation of robot can be mathematically expressed in (4) where b is the distance between each wheel to the center of mass's robot, R_R and R_L are the gear radius of right tracking and left tracking, respectively.

$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} \frac{R_R}{2}\cos\theta & \frac{R_L}{2}\cos\theta \\ \frac{R_R}{2}\sin\theta & \frac{R_L}{2}\sin\theta \\ \frac{R_R}{2b} & -\frac{R_L}{2b} \end{bmatrix} \begin{bmatrix} \omega_R \\ \omega_L \end{bmatrix} \quad (4)$$

The current state of robot (x_r, y_r, θ) and the next state or goal (x_d, y_d, θ_d) variables are introduced in Figure 5. To move the robot reaching the goal state, two variable distance (d) and orientation between two points (α) are expressed in (5) and (6), then the control algorithm or motor commands are applied to reduce these two variables be zero.

$$d = \sqrt{(\dot{x}_r - \dot{x}_d)^2 + (\dot{x}_r - \dot{x}_d)^2} \quad (5)$$

$$\alpha = tan^{-1}\left(\frac{\dot{y}_r - \dot{y}_d}{\dot{x}_r - \dot{x}_d}\right) \quad (6)$$

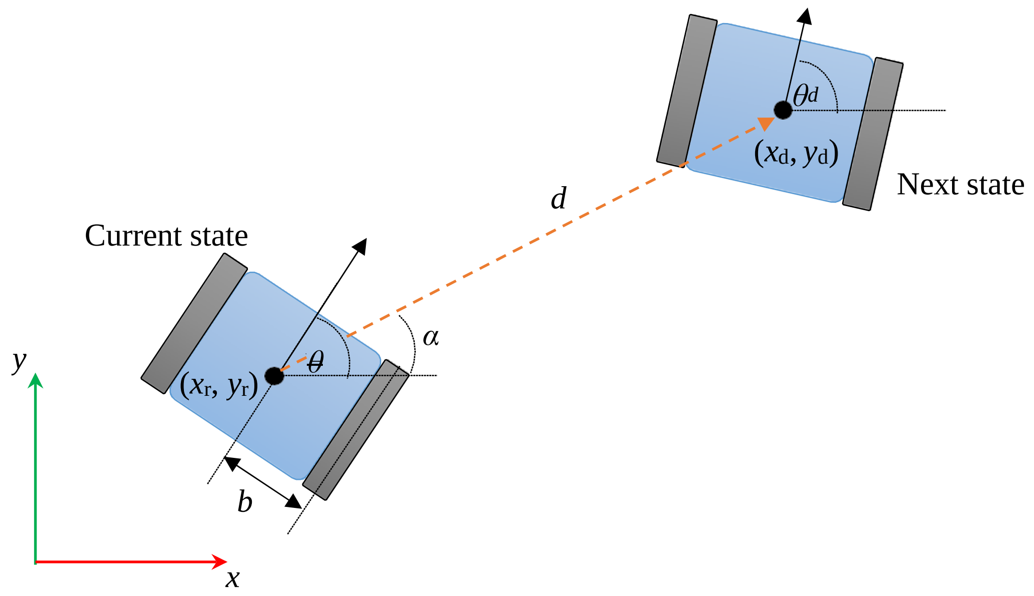


Figure 5. Kinematic model of robot

After students finish all activities above, they use all information to design the control system. The outcome of this topic is students be able to write a program to control the robot based on the kinematics of robot. However, there many sensors require to acquire all current states of robot. The vision sensor is one of widely used sensor in industrial applications. Some information can be extracted from image data by using image processing.

The last content, students learn machine vision method to estimate the guidance. Figure 6 shows the video capture of robot traveling along the demonstrating paddy field. Thus, in this situation, students have the procedure for two steps. First is to detecting crop and then to estimate the row as a local guidance for the robot. Students can use raw data of sensors from the recode to train a neural network. At the end of the course, students integrate all the contents in purpose to control robot in the application that they design.

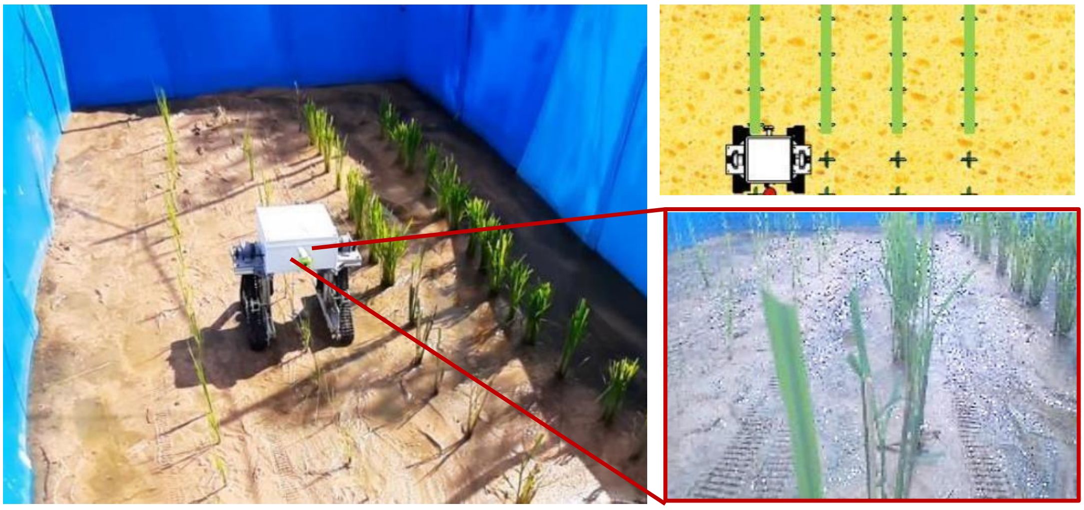


Figure 6. Example of learning machine vision

4. Conclusion

In this study, we developed a tool which is autonomous mobile robot with machine vision to gain students achieve based on learning outcomes of robotic course. Students will learn from the basic until complex concept. At the end of study in the course, we expected that students will reach all the goal of course learning outcomes. Moreover, students can create situation in the real world and solve the problems by using mobile robot. The next step of this study, we will use a mobile robot in the class and collect the student perceptions in learning robotic course to determine on the quality and quantity of education.

Acknowledgements

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Developing a Low-cost Rotary Series Elastic Actuator for Mechatronics Engineering Students

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Abstract: Mechatronics engineering students is taught a multidisciplinary approach for problem solving and system integration in industrial field. Students have learnt relevant subjects, but some contents are mismatched with the industrial requirements. In motion control, students should handle the vibration and external force that may occur by using various feedback control techniques. This study proposes the development of low-cost rotary series elastic actuator as a learning tool for motion control or force control. It consists of driven unit, power transmission and elastic elements connected in series that can be designed, manufactured and control by students. Not only motion control but also force control can be archived. After design and test, student will gain practical skills, how related learned subjects and solving problems.

Keywords: Series elastic actuator, learning outcome, engineering education

1. Motivation and Introduction

Mechatronics Engineering is a multi-disciplinary field of engineering that integrates the different subject areas such as mechanics, electronic, control system and computer science. Thus, students are taught a multidisciplinary approach to problem solving and systems integration, and ready to learn a new technology. Nowadays, Collaborative robot or Cobot has been introduced in the industrial applications because it performs like a traditional robot arm and safe for nearby workers. The key important technology is that applying force/torque control. Several commercial collaborative robots utilized a force/torque sensors to measure the contacting force directly for high precision result. The drawback is that the equipment cost is expensive, and it requires the specialist to operate and maintenance. Some implements the indirect force sensing method by estimating the interaction force from the displacement of elastic elements. Series Elastic Actuator (SEA) which is indirect force sensing and compliant actuator is one of interested topic for robotics engineering research because they do not only apply the motion (position/velocity) control but also the force control.

However, gap between what student have learned and what the industrial requirement was identified (Čech, M., et.al. 2019). The paper addressed that the grown of motion control technology goes faster than motion control education. For example, control courses demonstrate modelling and control design methods by using first-order or second-order system. While as the student should be prepared how to handle the vibration using feedback control techniques. To meet industrial requirements, several research works used the industrial or automotive part for education in the system dynamics topics. Ismail M.A.B et.al. (2019) proposed the using Magnetorheological suspension for studying Spencer model. McPheron, et.al. (2016) proposed the low-cost two-degree-of freedom mass-spring cart system for system identification laboratory exercise. Not only system dynamic, also the concept of force control was proposed as educational kits for students and graduated students.

HandsON-SEA which is admittance-type device, was presented to complete with the impedance-type Haptic Paddle design (Okamura, A.M., et.al., 2022) for teaching a workshop on force control (Otaran, A., et.al., 2016). Javaid, A. et.al., (2019) proposed a low-cost force feedback devices to improve learning in STEM+C. The proposed device has a larger workspace and higher force output and the ability to render free space in haptic applications. "EduExo" (2022) was also introduced as the force feedback wearable device for 1-DOF elbow joint. Both of works utilized 3D printed parts, low-cost sensors, and actuators, then the device looks affordable for students and force rendering is archived.

The previous works focuses on 1-DOF device for force control with nonindustrial parts, then students may be not familiar with the components. The systems dynamic model is modelled as lumped mass which the unmodelled behavior is not presented. In this work, the prototype of low-cost rotary series elastic actuator is described in how to design and develop with a low-cost component for mechatronic and control engineering students.

2. Conceptual framework

2.1 Learning outcome

This work proposed the design of rotary series elastic actuator to enhance mechatronics students based on relevant subjects. The basic concept of actuator design and control for students should be learned based on learning outcomes as follow:

Table 1. *Actuator Design Learning Outcome*

Course concepts	Learning outcomes
1. Principle of mechanical engineering	- Design mechanical parts, adjustable load, and elastic elements
2. Power transmission	- Design, manufacture a gear reducer - Verify prototype
3. System dynamic and control	- Synthesize the mathematical model - Design the controller gains
4. Embedded system	- Design embedded system and electronic - Write a program for embedded system - Apply a control algorithm without using library

3. Development of a low-cost rotary series elastic actuator

The rotary series elastic actuator is used as a learning tool for two-mass-spring-damping model in rotational motion and force control system. The target specification is to provide the output torque at 4 Nm in maximum, and the angular speed is limited at 180 degree/s or 30 RPM which is based on commercial Cobot specification. As shown in Figure 1, the design of rotary series elastic actuator consists of driven unit (DC brushed motor), power transmission, elastic elements, and mechanical load, which each part can be re-configured. A DC motor drives the load through the gear reducer for reducing the output speed and increasing the output torque. However, the output torque does not apply to the load directly, the elastic elements was installed between gear reducer and load to measure the interaction force which is proportional to the stiffness of torsion spring and the angular displacement. Thus, this work has two incremental encoders to measure the angular position of motor and the angular position of load. The difference between these can be estimated the static external torque by using (1)

$$T_s = K_{eq}(\theta_l - N_{-1}\theta_m) \tag{1}$$

Where T_s is the static torque/moment, K_{eq} is the equivalent stiffness of torsion spring, N is the gear ration, θ_l and θ_m are the angular position of load and motor shaft, respectively.

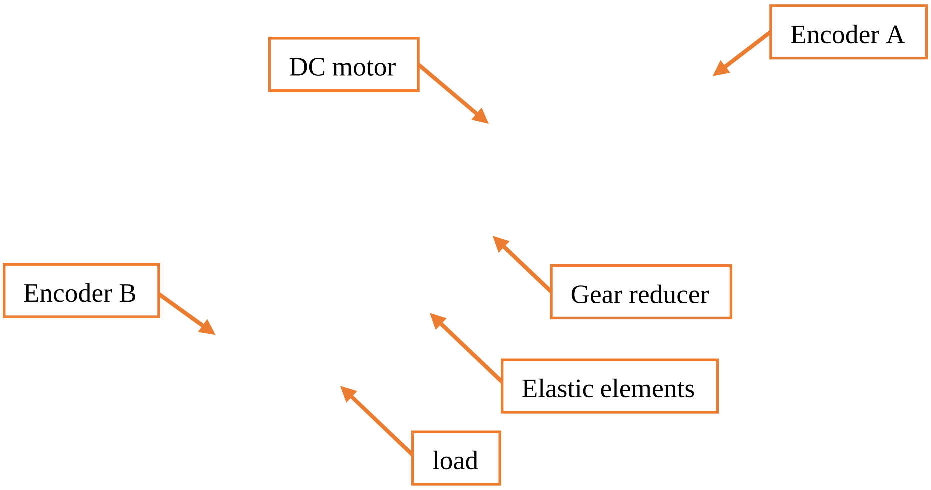
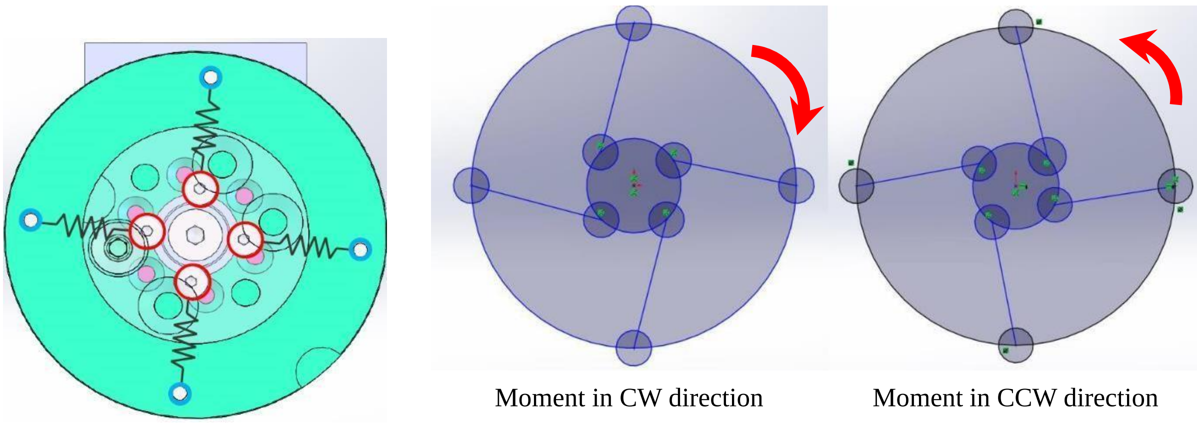


Figure 1. Components of rotary series elastic actuator.

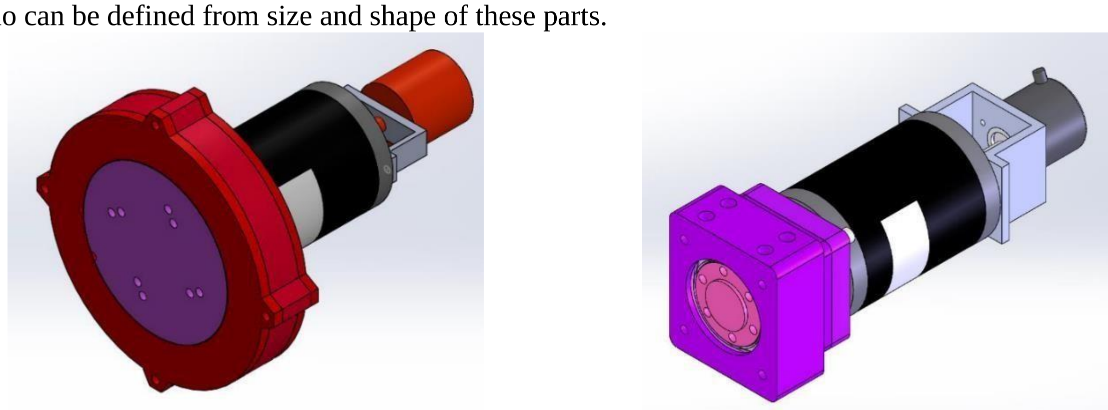
For elastic elements, students can design and select any type of elastic elements. One design consisting of four tension springs is illustrated in Figure 2, which is easy to construct but it is difficult to identify the equivalent torsion stiffness value, algebraically. Thus, they can conduct the experiment by taking the various loads and record the angle displacement.



Moment in CW direction   Moment in CCW direction

Figure 2. Elastic elements design.

For power transmission part, student can design and select type of gear reducer based on gear ratio number. The required gear ratio is calculated from the rate speed of DC motor and the required speed, then 3500/30:1 or 116:1. Considering among types of gearheads, cycloid gear reducer is high ratio in compact sizes. It has four main parts: cycloid disc, roller, output, and Crankshaft, which the gear ratio can be defined from size and shape of these parts.



a) Cycloidal Drive   b) Dual Stage Cycloidal Drive

Figure 3. Power transmission design

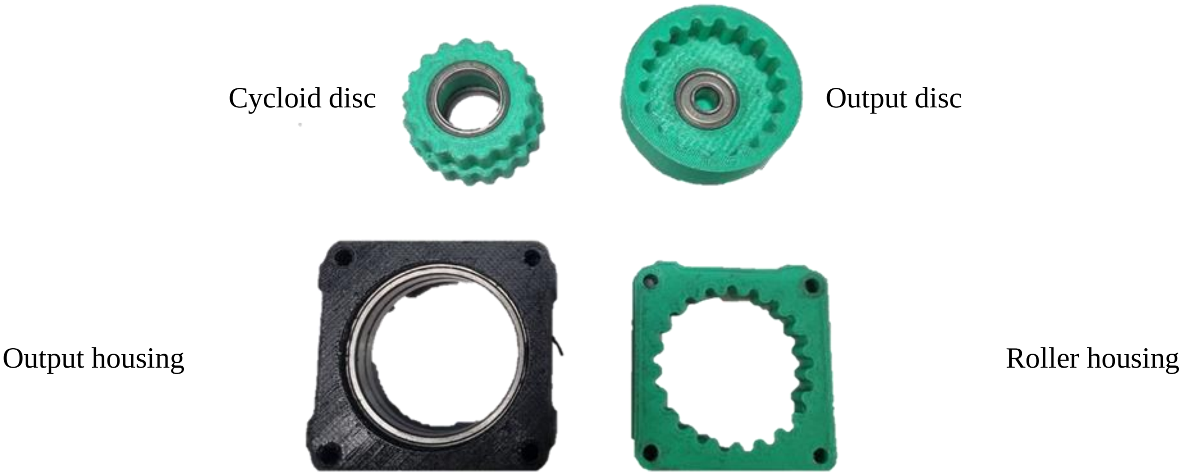


Figure 4. Prototypes of dual cycloid

For controller design of position and force control, student needs to find the relationship between motion and torque acted to the device. To achieve, the mathematical model of each part has been derived by a free body diagram, then MATLAB Simulink toolbox is used to simulate the system dynamic behavior and design the controller in Figure 5. By connecting signals among the block diagrams, student can easier link between actual components and system block diagram.

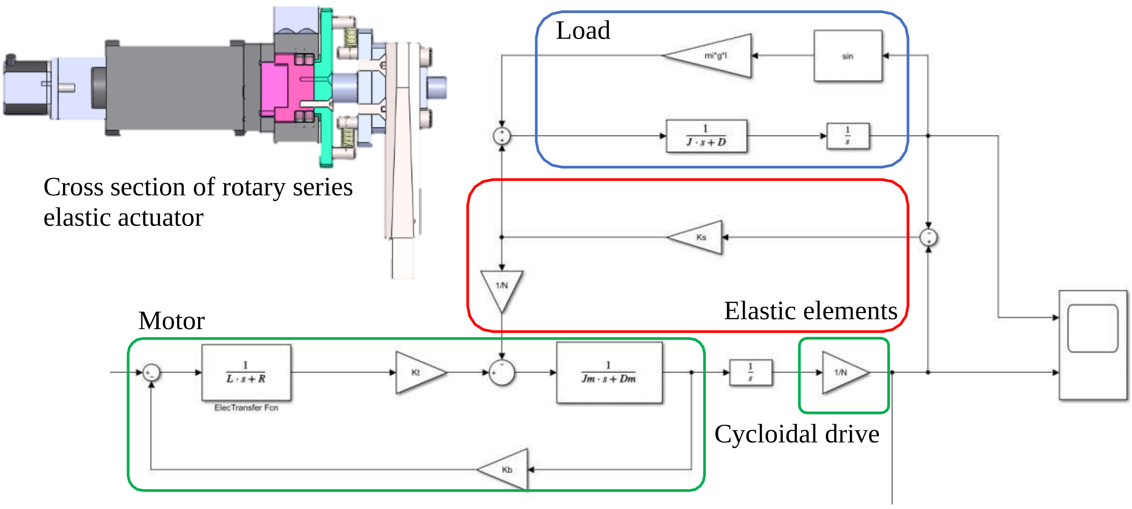


Figure 5. block diagram of rotary series elastic actuator systems

The approximate cost of protype is shown in Table 2, which is breakdown as mechanical parts, sensors, PLA filaments, electronic and microcontroller. The total cost represents the cost of new items while as students can purchase some parts for redesign which are available in the market such as PLA filament and electronic parts. By using 3D printer for building the prototype components, there is no manufacturing costs.

Table 2. *Cost of components*

Components	**Qty.**	**Net cost (USD)**
DC motor	1	25.00
Mechanical bearing	5	50.00
Tension Springs	4	20.00
Encoder	2	80.00
PLA filament for 3D printer	1	20.00
Motor Driver	1	25.00
Microcontroller board (STM32)	1	25.00
Screws, wiring cables, connectors	1	20.00
Total cost		265.00

4. Conclusion

Since the grown of motion control technology goes faster than motion control education, mechatronics engineering students have learnt the relevant subjects in the fundamental that causes the gap between the content student have learnt and industrial requirements. When students graduate, it is tough for linking their knowledge and real applications even though they have problem-solving skill and be ready adapted for a new technology. This work, we introduce a low-cost rotary series elastic actuator which involve with position control and force control. The device consists of driven unit, power transmission and elastic elements connected in series that can be designed, manufactured and control by students. Based learning outcome, students need to integrate their knowledge in principle of mechanical engineering, power transmission, system dynamic and control to model and analysis the system behavior.

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Ask4Summary Automatically Responds Student's Question with a Summary Assembled from Course Content

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Abstract: This work-in-progress paper presents a Moodle plugin that parses a Moodle course's text-based learning materials in various format (e.g., Microsoft Word DOCX file, Microsoft PowerPoint PPTX file, PDF file, web pages in HTML form) as well as a student's question posted on a discussion forum on Moodle with Natural Language Processing techniques (e.g., n-gram model) and search engine similarity calculation method (i.e., Cosine Similarity). The Ask4Summary acts like an online tutor can automatically answers a student's question with a summary assembled via matching and retrieving from the stored information. The research team has also planned an evaluation on using the Ask4Summary in a graduate level academic writing in English course and explained its details at the end of this paper. Last but not the least, the Ask4Summary could be an online representative not only for online learning but is also capable of helping users on their questions regarding products, healthcare, etc. if there are correspondent text-based materials existing for Ask4Summary to read in advance.

Keywords: Moodle, Plug-in, N-gram, Language Learning, Cosine Similarity, Discussion Forum

1. Introduction

The information overload caused by technological development might influence student's learning performance (Feroz et al., 2021). Natural Language Processing enables information extraction and automatic text summarization in the many fields (Bommarito II et al., 2018; Gambhir & Gupta, 2017). El-Kassas et al. (2021) suggest future research works focusing on multi-document, user-specific and innovative text summarization applications.

N-gram is a computational language model in NLP, is based on a Markov chain that only accounts for the sequence of n components of a text (Russell & Norvig, 2022). To reduce the ambiguity inherent in natural language, the n-grams can be grammatically classified and labelled the words according to their part of speech (PoS) tags (Wilks & Stevenson, 1998). This paper talks a work-in progress research project, Ask4Summary. The Moodle plugin adopts an open access web service of *N-gram & PoS Identifier and Verifier* that is trained with DBpedia (https://ngrampos.vipresearch.ca/) and implements a semantics based vector space model algorithm (Salton et al., 1975) as well as the cosine similarity method (Pal, Chang, & Iriarte, 2022).

Moodle is a widespread open-source learning management system used in diverse educational options (e.g., schools, universities) (Al-Ajlan & Zedan, 2008). Approximately, there are 172,000 registered Moodle sites in the world, 41 million courses and 327 million users, according to official statistics (https://stats.moodle.org/). The open-source plugin, Ask4Summary, can be considered as an online computerized tutor that can provide the summary of the course text-based learning content, in a timely manner, for a student's question posted in the discussion form. Ask4Summary can be download and installed in any Moodle course for free. Therefore, many learners can benefit from the research.

This paper is structured as follows: Section 2 introduces the Ask4Summary Moodle plugin and explains the configuration process for teachers. Section 3 describes how students ask question and what response they can see as well as how teachers can check what questions and the correspondent summary within the Ask4Summary plugin. Section 4 proposes an evaluation plan for assessing the usability of the Ask4Summay plugin and the perceived satisfaction toward the generated summary Ask4Summary Moodle Plugin

Online learning and teaching do not mean that putting course materials online and asking students to learn by themselves. It is important to provide students supports when they encounter questions about course content or materials. When students ask their question on a discussion forum in an online learning environment, sometimes there may have no one available at that time to help them due to time differences or study behaviors and needs – for instances some students may have family/children/baby and day job and they might not be able to do their study until late night or weekends. This leads to an obvious conclusion that if a system was in place to provide an automated summary, this could facilitate learning. Having an easily accessible system, which can quickly provide responses, allows students to get information that may have otherwise been difficult to find.

Ask4Summary is a block type Moodle plugin designed to provide summaries relating to a student's question (https://moodle.org/plugins/block_ask4summary). The details of its general process and workflow can be found at (Saleh, Iriarte, & Chang, 2022, 2022). Figure 1 shows the Ask4Summary block at the right-hand side on the Moodle course page after it is added into a course.

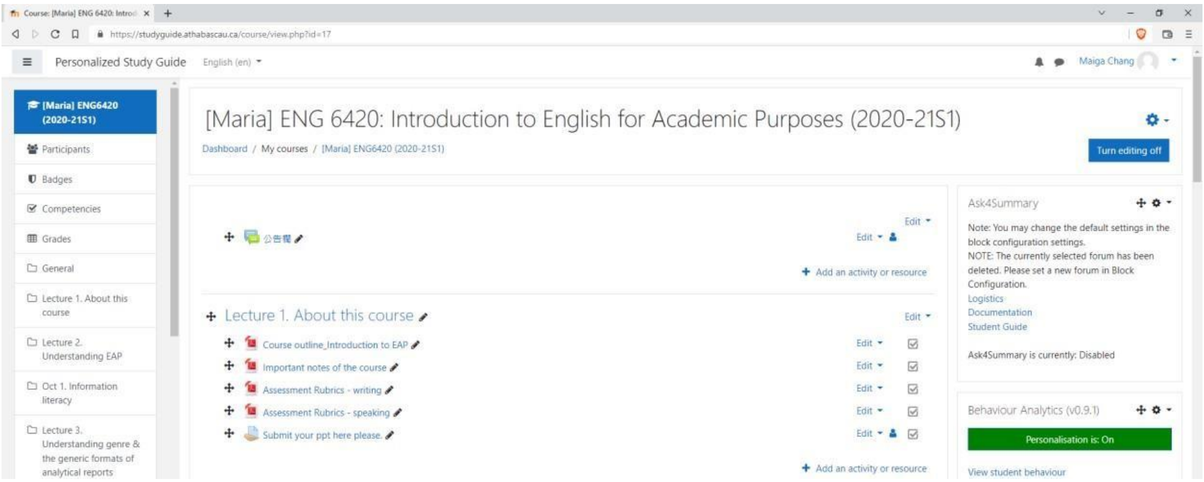

Figure 1. Ask4Summary plugin.

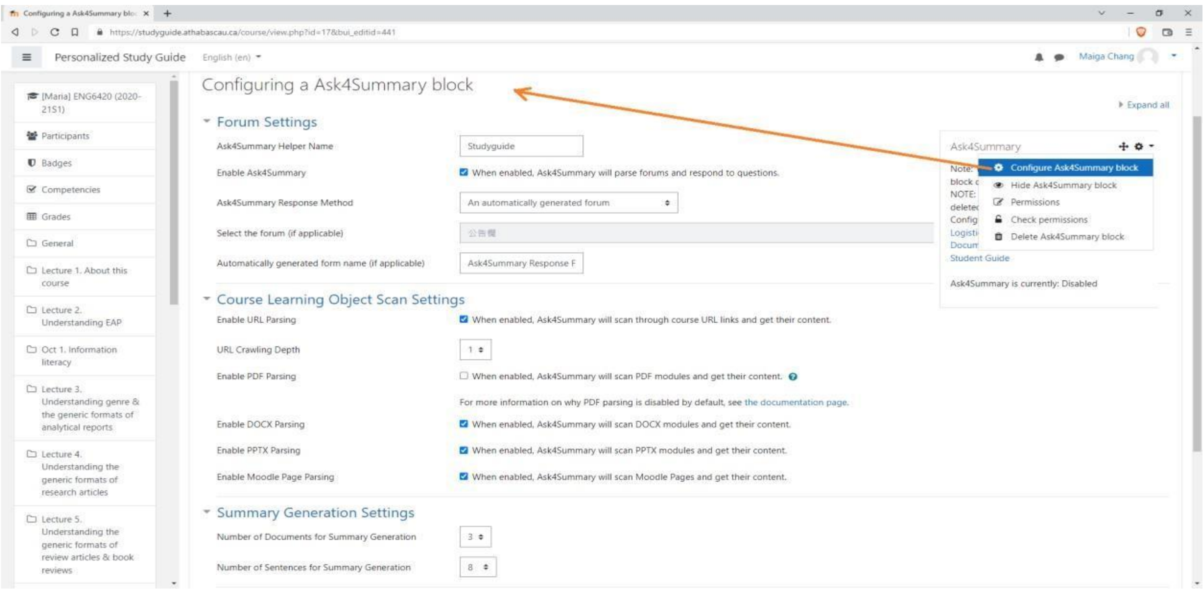

Figure 2. Teachers can change various settings on their own.

Teachers can configure the block in their courses by turning on the edit and then choosing “Configure Ask4Summary block” from the gear icon of the block as Figure 2 shows below. The first thing the teachers should change is the “Helper Name” and the “Ask4Summary Response Method”. Ask4Summary will only respond student’s question posted in the designated discussion forum that the teachers chose in the “Ask4Summary Response Method” and the posting contains the “Helper Name”. The scenario in Figure 2 indicates that the Ask4Summary will scan the automatically generated forum for the postings where “Studyguide” is found.

Teachers can also select an existing discussion forum in their course for students to ask questions and for the Ask4Summary to scan and respond as Figure 3 shows. The next important setting that teachers should consider is “what formats of learning materials in a course they want Ask4Summary to read in advance for responding students’ questions”. Ask4Summary can read webpage in HTML format as well as documents in Microsoft Word/PowerPoint formats (i.e., DOCX/PPTX files). While it can also read PDF documents, the Moodle server needs to have application AbiWord pre-installed and setup by system administrator. Last but not the least setting that teachers should configure is “how many documents at the end and how many sentences in them the Ask4Summary should consider while producing the summary for student’s question”.

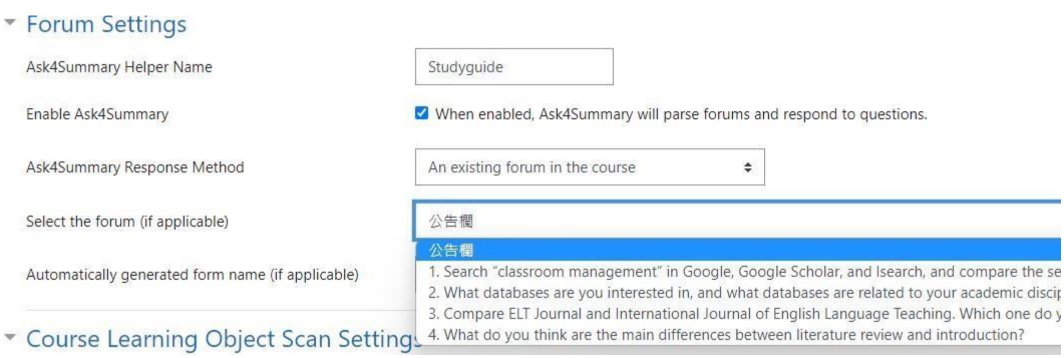

Figure 3. Teachers can choose an existing discussion forum for Ask4Summary.

Once the teachers complete the configuration and save the changes, the Ask4Summary will be enabled as Figure 4 shows. A discussion forum, “Ask4Summary Forum”, is generated for students asking questions and for the plugin to scan and respond the questions. Students now can ask questions by posting in that particular forum.

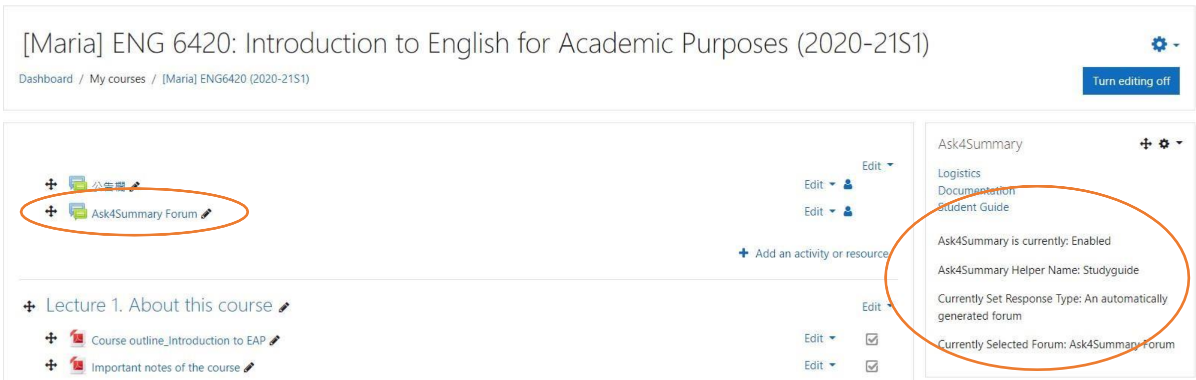

Figure 4. Ask4Summary plugin’s status and info.

However, before the Ask4Summary can respond any student’s question, it has to read all selected learning materials in the course. When the teachers click “Logistics” link in the block of Ask4Summary, they can see Figure 5. The logistics page not only shows the numbers of learning materials in different formats that the Ask4Summay is processing but also show which unit or learning activity a document belongs to. Teachers can check its reading progress and know when their students can start asking questions for the Ask4Summary.

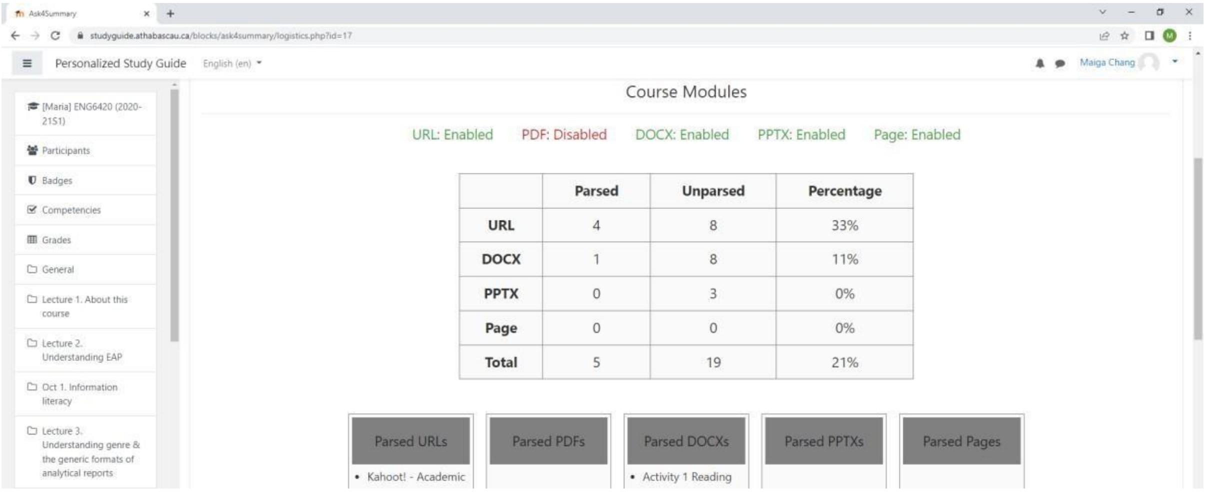

Figure 5. The Progress Table found in the Logistics Page.

In general speaking, a course like Figure 5 shows can be read and parsed quickly. However, Figure 6 shows that by default the Ask4Summary only scans all documents once a minute from the midnight to early morning at 6 AM, while it will scan for students' questions every 15 minutes – these settings are making sure the Ask4Summary will not slow the server down and cause problem for students' learning as most of students might not do learning activities in that period. Of course, the Moodle administrators can change the frequencies of scanning documents and discussion forums according to their institution needs at any time.

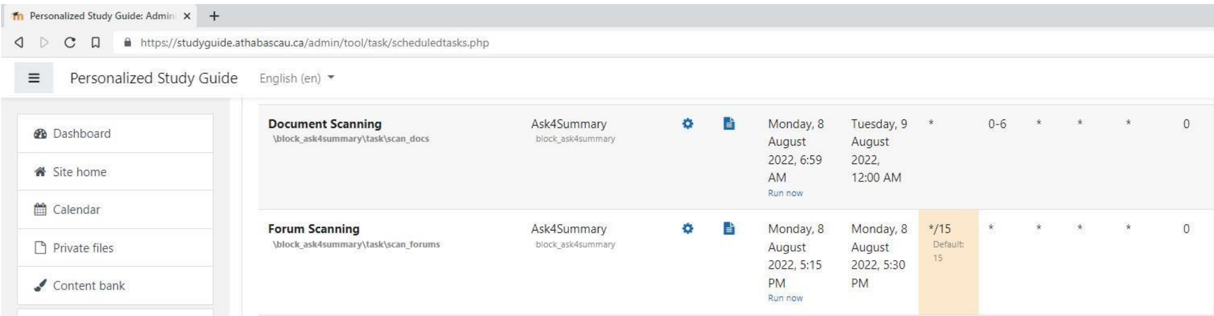

Figure 6. The Progress Table found in the Logistics Page.

2. Question Asking and Summary Generation

As been mentioned earlier (see Figure 6 above) every 15 minutes Ask4Summary begins its "Forum Scanning" task, it retrieves all the course's forum posts that contain the specified the Helper Name. Then, it follows the same process it reads and processes the course materials. Figure 7 below shows a student posting a question with the subject "Hi Studyguide" that contains the Helper Name and the question "what should I avoid when writing".

When Ask4Summary finds a question just posted in the last 15 minutes is like another question that it generated the summary and had responded before, then it will reuse the earlier generated summary to respond the question for time and effort saving purpose. Teachers can always check the Answered/Unanswered posts section at the bottom of the block's logistics page (see Figure 8 below). From the Answered Posts section, they can tell which questions were considered by the Ask4Summary to be similar and what content the Ask4Summary included and generated for responding. The teachers can of course always respond the post and its replies to make further explanations and clarifications.

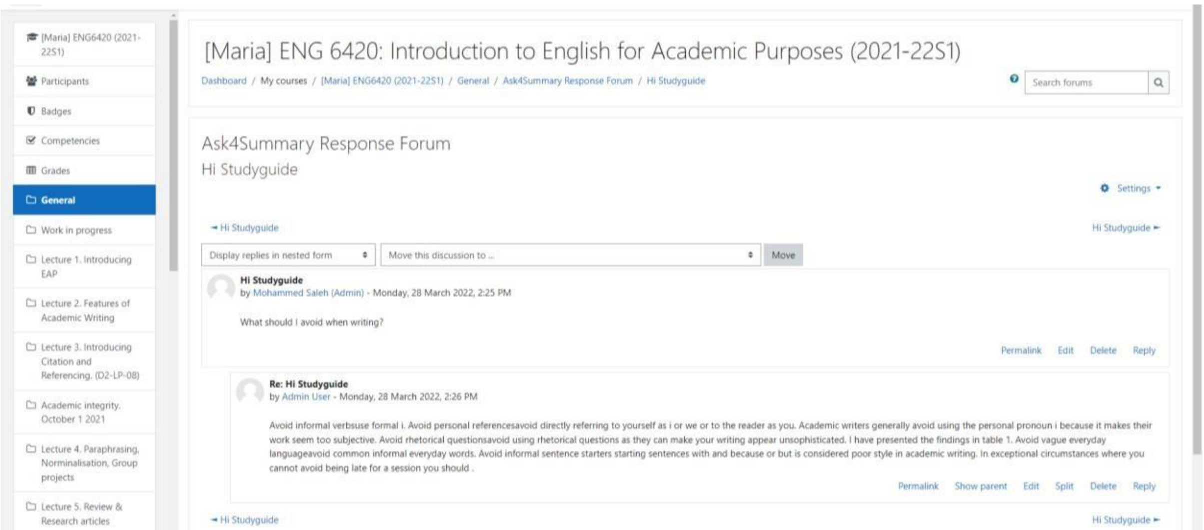

Figure 7. The posted question and the response from Ask4Summary with the generated summary.

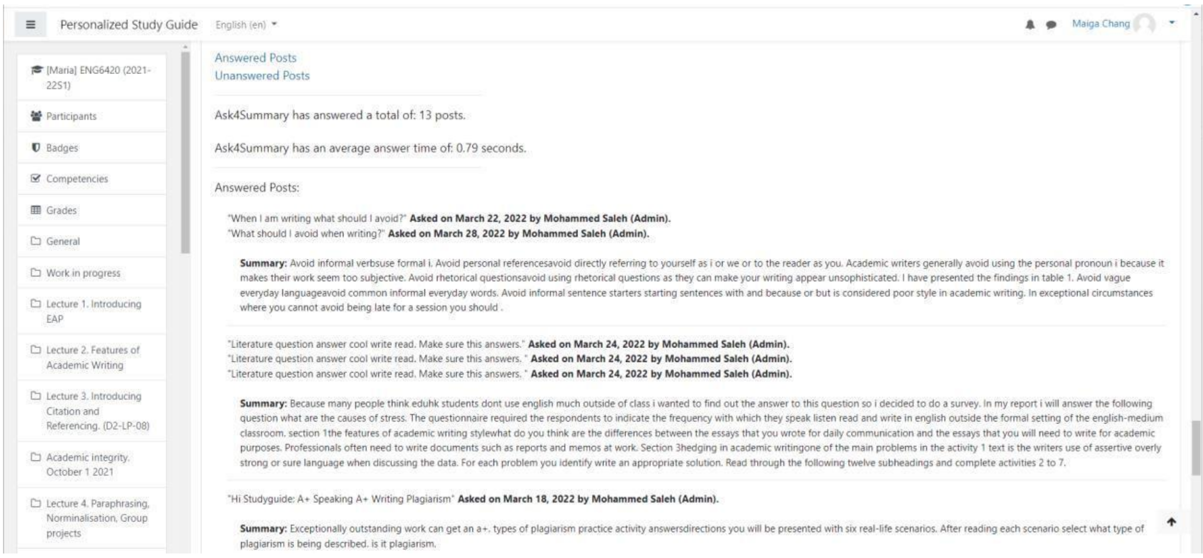

Figure 8. The teacher can check all summary generated and responded by Ask4Summary.

3. Evaluation Plan

Technology Enhanced Language Learning (TELL) originated in the 1950s with the first language learning programs for military purposes (Tafazoli et al., 2019). The introduction of technology in language learning has resulted in favorable outcomes (Ahmadi, 2018) and Heil et al. (2016) found that TELLs use a learner-oriented approach and explanatory feedback might perform better than rigid methodologies. Slavuj et al. (2015) consider that the use of NLP can make the TELL evolve from the corrective feedback to the interactive tutoring systems focusing on individual students' needs. Recent research confirms that automated personalized feedback provided by Intelligent Tutoring Systems (ITSs) promotes student knowledge acquisition (Al-Bastami & Naser, 2017; Kochmar et al., 2020).

The Ask4Summary Moodle plugin meets the trend in TELL research area because it acts as an online tutor that responds student's question in a timelier manner by generating a summary according to the course learning materials. To verify the usability and effectiveness of Ask4Summary, the research team has a plan to have the Ask4Summary plugin adopted and used in a graduate-level Academic English course through a partnership with an Asian university. A questionnaire following a common procedure in information systems research (Recker, 2021) is designed. The questionnaire focuses on several aspects of the system: usability, perceived relevance and satisfaction.

The data analysis starts a review of the asked questions and the correspondent summary generated by Ask4Summary to check the teacher's perceived relevance and satisfaction degree. As students' perceived relevance and satisfaction toward the summary generated for their questions are also collected, the research team is going to study the relevance and satisfaction degrees (in score 1 to 10) respect to the summaries not only with the means of descriptive statistical analysis but also discuss with the teacher the potential reasons for (1) why students perceived that way if they disagree from the teacher's perception and (2) what are the problems a generated summary has. The potential problems identified by the teacher could help the research to change and improve Ask4Summary further.

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Research Hotspots and Trends of Educational Ethics of Artificial Intelligence in China

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Abstract: The ethical issues in the application of artificial intelligence education have attracted increasing attention. This paper takes 205 literatures collected in CNKI database as the research object, analyzes the institutions and keywords by using CiteSpace, an information visualization software, and reveals the research hotspots and development trends of artificial intelligence education ethics in China. The results show that the research hotspots of AI educational ethics in
China focus on AI, educational ethics, education, higher education, AI era, practical path, etc. The research has a long history, but it is still in the primary stage, so researchers need to conduct more in-depth and detailed research in this field. For this reason, the article gives further summary and thinking, with a view to providing reference for the in-depth study of AI education ethics.

Keywords: Artificial intelligence, Education; Ethics, CiteSpace, Visualization analysis

1. Introduction

In March 2019, the Ministry of Education issued the Key Points of Education Informatization and Network Security in 2019, which clearly pointed out that: "It is required to open artificial intelligence related courses in primary and secondary schools and promote the in-depth application of new technologies such as big data, virtual reality and artificial intelligence in education and teaching." (Zhang Mian,2020). However, with the continuous breakthrough of artificial intelligence technologies such as pattern recognition and machine learning, the application of artificial intelligence in education is also faced with a series of ethical issues such as data security, privacy protection, and the role transformation of teachers and students. This paper aims to explore the research hotspots and trends of AI education ethics in China, in order to provide reference for further research on AI education ethics.

2. Data Sources and Processing

This study mainly analyzes the keyword frequency, clustering, and hot spots of the literature related to educational AI ethics in China in recent years, and searches on CNKI database. Through CNKI's "Advanced Search", the topics of "Artificial Intelligence", "Education" and "Ethics" were selected for literature search. By June 25th, 2021, 314 literatures had been retrieved, and qualified literatures were screened out through manual filtering. Finally, 205 literatures were selected for visual analysis, including journals, dissertations and conference papers.

CiteSpace visual analysis tool used in this study is an information visualization tool developed by Professor Chen Chaomei of Dressayre University, USA, which is suitable for multivariate, timesharing and dynamic complex network analysis (Wang Juan et al.2016). Export 205 documents to Refworks format, open CiteSpace software, click the "CNKI" label in "Import/Export" for format conversion, and use the converted data for analysis. The time span is 2000 ~ 2021, and the interval is 5 years, respectively, to analyze institutions and keywords. CiteSpace provides three views, namely, cluster graph, timeline graph and time zone graph. This paper presents the final analysis map by static clustering and visualization of the whole network.

3. Data analysis and discussion

The purpose of this paper is to analyze the current research situation of AI education ethics in China, draw the amount of relevant documents published in recent years by Excel, investigate the research results of the integration of AI, education and ethics, analyze the high-yield institutions of AI education ethics by CiteSpace, analyze the research hotspots and trends of AI education ethics by keyword cooccurrence, clustering and time series diagram, and reveal the research frontier and direction of AI education from an ethical perspective.

3.1 Time distribution map of AI education ethics research

According to the statistics of 205 articles, as shown in Figure 1, all the articles were published in the last five years. From the quantitative trend, the number of articles published increased year by year, reaching the peak in 2020. However, as the statistical time ended in June 2021, the number of articles published in 2021 was still considerable, and the overall research showed an upward trend. In April, 2021, Huawei, which has invested more than five years in the field of automatic algorithms, announced that its driverless technology has reached L4 level, bringing another breakthrough to AI. Under the guidance of national policies in the future, the application of artificial intelligence technology in the field of education will only be more and more. While the educational reform caused by technology brings us numerous conveniences, it is bound to also cause ethical, moral and even legal problems. In the future, more and more scholars will begin to pay attention to and study the ethical problems and ethical governance in this field.

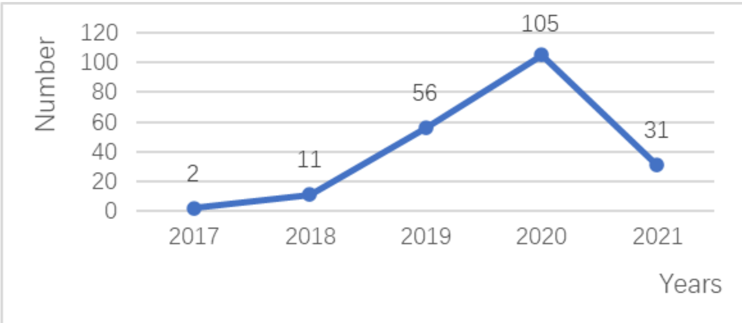

Figure 1. Literature statistics of educational ethics of artificial intelligence in China.

3.2 Figures and Table Spatial distribution map of AI education ethics research

In order to find out the core academic groups and institutions of AI educational ethics research in China, this study counted 205 research institutions of literature, and through CiteSpace co-occurrence analysis, we got a co-occurrence map of institutions in AI educational ethics research field with 61 nodes, and further sorted out the scale of articles issued by the core institutions with a starting volume greater than or equal to 2, as shown in Table 1. As shown in Table 1, Shanghai Education Press Headquarters, China Academy of Science and Technology Development Strategy, Jiangnan University School of Education, and East Normal University Department of Education are the institutions with the largest number of publications, and the publication year of these institutions is earlier than that of other institutions, which shows that these institutions are rich and mature in the research of AI education ethics, and they are representative institutions in this field. The China Academy of Science and Technology Development Strategy, as a public institution directly under the Ministry of Science and Technology, and the Education Press Headquarters directly under the Shanghai Municipal Education Commission, are enough to show that the state attaches great importance to the ethical research of it. In addition, on the whole, the research institutions in this field are mostly the education departments of universities and

Marxist colleges, which also shows that this research is an interdisciplinary field of education and Marxism.

Table 1. *Core institutions in the research field of artificial intelligence education ethics*

Serial number	Quantity of documents issued	Starting year of publication	Organization
1	5	2000	Shanghai Education Press Head Office
2	5	2000	China Academy of Science and Technology Development Strategy
3	3	2000	Jiangnan university education college east China normal university education department
4	3	2021	Capital Normal University
5	3	2018	East China Normal University Education Department
6	2	2019	Beijing Normal University Wisdom Learning Research Institute
7	2	2020	Jiangnan University Tian Jiabing College of Educational Sciences
8	2	2018	Marxism College of Shanghai Normal University
9	2	2020	Guizhou Normal University Education College
10	2	2020	school of journalism and communication
11	2	2020	Northeast normal university education department
12	2	2018	Marxism College of South China Normal University South China Normal University Value Education Research and Development Center
13	2	2020	Qufu Normal University Media College
14	2	2020	Yunnan University Institute of Higher Education Yunnan university Marxism college
15	2	2019	Communication University of China
16	2	2020	Lanzhou University Media College Northwest Normal University Media College

3.3 Research focus of AI education ethics

From the perspective of knowledge theory, keywords with high centrality and frequency represent the common concerns of researchers, that is, research hotspots. Centrality, as a measure of the power of a node, reflects its importance in the network. The higher the co-occurrence frequency of keywords, the higher the point centrality, indicating that nodes are more important in this field(Wang Juan et al.2016). As shown in Table 2, keywords with high frequency in domestic research literature include artificial intelligence, ethics, intelligent age, artificial intelligence education, education, higher education, intelligent education, etc., which reflects the focus and migration of ethical research on AI education in China in the past twenty years.

Table 2. *Co-occurrence frequency, centrality and year of keywords*

Serial number	Frequency	Centrality	Age	Keyword	Serial number	Frequency	Centrality	Age	Keyword
1	119	0.85	2017	artificial intelligence	12	5	0.12	2020	Educational ethics
2	11	0.31	2018	ethics	13	5	0.03	2020	teacher
3	10	0.14	2000	Intelligent age	14	4	0.19	2018	Ethical risk
4	9	0.13	2017	Artificial intelligence education	15	4	0.04	2018	Wisdom Education
5	9	0.36	2018	education	16	4	0.35	2018	Educational big data
6	8	0.12	2018	higher education	17	4	0.22	2019	Artificial intelligence education
7	7	0.27	2019	Intelligent education	18	4	0.06	2019	transformation
8	5	0.01	2000	difficult position	19	4	0.03	2020	teacher-student relationship
9	5	0.02	2000	Risk management	20	4	0.06	2020	ideological and political education
10	5	0.13	2019	big data	21	4	0.07	2020	Philosophy of technology
11	5	0.12	2019	Artificial intelligence era	22	4	0.06	2020	Technical ethics

Through the cluster analysis of key words, as shown in Figure 2, there are 11 hot research topics such as artificial intelligence, educational ethics, education, higher education, artificial intelligence era, practice path, artificial intelligence education, reform, ideological and political education in curriculum, practice path and big data. The number in front of the keyword represents the cluster number. The smaller the cluster number, the more keywords it contains. The clustering module value (Q value) in the clustering result is 0.7235>0.3, which means that the clustering structure is significant; The average contour value (S value) of clustering is 0.9164>0.7, which means that clustering is very convincing.

Figure 2. Cluster Atlas of Ethical Key Words of Artificial Intelligence Education

3.4 Research trend of artificial intelligence education ethics

On the basis of the cluster diagram, this study counted the time series diagram of the frontier keywords of AI education ethics in China by time segments (every five years), as shown in Figure 3. Around 1999-2000, the concept of the intelligent age began to appear. At that time, some scholars had already paid attention to the ethical issues of educational data, as well as the risks, dilemmas and practical paths faced when entering the intelligent age. With the continuous progress and development of science and technology, the ethical research of artificial intelligence educational concern is booming. No matter from the technology itself, the whole educational ecology, or a single teaching mode, the ethical problems brought about will be studied and concerned in the future.

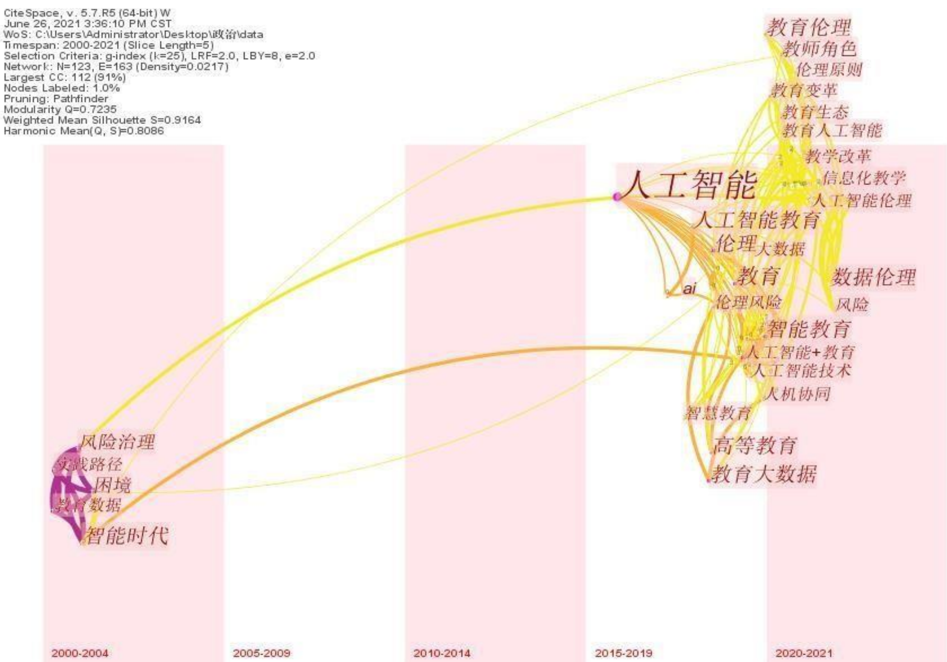

Figure 3. Time series diagram of keywords at the forefront of artificial intelligence education ethics

4. Conclusion and Thinking

4.1 Research conclusions

In this study, CiteSpace software is used to analyze and visualize the atlas and related data generated by the literature on domestic AI education ethics from 2017 to 2021 in CNKI database at different levels, and the following conclusions are drawn:

- ⋆ The time distribution spectrum shows that in recent years, the number of articles published on the ethics of AI education in China is on the rise, which shows that more and more scholars are beginning to focus on ethical issues in it, and they also expect that future research in this field will attract more people's attention and thinking.
- ⋆ The spatial distribution map shows that under the leadership of the National Institute of Science and Technology Development Strategy, there are many institutions that study the educational ethics of artificial intelligence, and they are also the core institutions in this field. However, because the research is in the primary stage, the number of articles published by relevant institutions is small. In the future, it is necessary to strengthen the research in this field, as well as the cooperation and integration among education, philosophy, science and other fields, to establish a community and a long-term development mechanism, and to promote a virtuous circle of AI education ethics research.
- ⋆ The keyword co-occurrence and cluster map show that the research hotspots in the field of AI educational ethics focus on AI, educational ethics, education, higher education, AI era, practice path, AI education, reform, curriculum ideological and political education, practice path and big data. The research topics are mainly distributed in practice path, reform, curriculum ideological and political education, big data and so on, which also reflects that the research is dominated by national policies. Under the guidance of educational and teaching reform and deepening the reform and innovation of ideological and political theory courses in schools in the new era, the research focuses on constructing ethical principles such as engineering ethics, technical ethics and data ethics in education, and exploring the ethical practice path of the application of artificial intelligence education, aiming at cultivating people's ethical consciousness.
- ⋆ The time sequence diagram of research frontier shows that the frontier of AI education ethics in China is embodied in education ecology, ethical principles, teacher's role, education reform, information-based teaching, data ethics, man-machine cooperation, and intelligent education. This reflects the characteristics of strong interdisciplinary and interdisciplinary integration, but the research scope is large, the research points are scattered, and there is a lack of specific research direction. Therefore, researchers need to conduct more in-depth and detailed research in this field.

4.2 Research and thinking

While AI brings us powerful data integration and analysis ability, it also brings many educational ethical problems and risks. In 2019, the European Commission published the Ethical Guidelines for Artificial Intelligence, which constructs an ethical framework from seven aspects to ensure that artificial intelligence is safe and reliable enough (Zawacki et al. 2019). The construction of the ethical principles of AI education can provide reference ethical norms for us in the research and development enterprises, deployment schools, and government supervision of AI education products (Shen et al. 2019).

Based on the existing research, the following three suggestions are put forward for the future application and development of AI in education: First of all, the existing AI education mostly stays in the field of knowledge and skills, ignoring the field of emotion and ethics. Therefore, the application of AI education should attach importance to emotional experience, people-oriented, student-centered, and strengthen ethical education. Secondly, at present, AI products are constantly emerging, but most of them are still in the stage of computational intelligence, not towards the stage of cognitive intelligence, and the technology is not mature enough to solve all the problems existing in the current teaching. In the future, it is necessary to further improve artificial intelligence technology, promote the deep integration of education and artificial intelligence, so that it products not only have "intelligence", but also pay more attention to "emotion". Finally, as "man-machine teaching" becomes a regular form of education, the role of teachers will change dramatically. AI will focus on "teaching" and teachers will focus on "education". Of course, the efforts of individual researchers alone are not enough. There is also a need to continuously increase the importance of the relevant departments of education and promote the participation of more teachers in relevant research. In addition, how to carry out teacher education and teaching innovation, so that machines and teachers cooperate in education, to achieve talent training in the era of AI, will become the focus of future research.

In the final analysis, education is human education. The essence of artificial intelligence is still a tool and a technology. Its application in the field of education cannot change the nature and purpose of education (Li Xiaoyan et al.2021). Therefore, in the application of AI education, we should give full play to the subjectivity of people, take the all-round development of people as the goal, use artificial intelligence technology to solve educational problems, and promote the development and innovation of education.

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Enhancing Learner Models for Pedagogical Agent Scaffolding of Self-Regulated Learning

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Abstract: Self-regulated learning (SRL) processes for monitoring and modulating one's own cognition, affect, metacognition, and motivation are essential for effective learning within intelligent tutoring systems (ITSs). As such, pedagogical agents are typically embedded within these environments to scaffold learners' SRL via prompts to engage in these processes. However, current pedagogical agents follow pre-established, production rules based on temporal and frequency inputs from the learner which limits the ability for these agents to provide individualized scaffolding intelligently and adaptively. In this paper, we argue that this issue originates from an underdeveloped learner model that does not comprehensively track the dynamic nature of SRL. This paper introduces recurrence plots, which visualize system dynamics, as a novel method for enhancing learner models to provide pedagogical agents the information necessary to interpret the dynamics of learners' enacted SRL processes captured using log files as they engaged with instructional materials during learning with an ITS. In merging recurrence plots and the field of SRL, learner models can be enhanced with information regarding learners' dynamical use of SRL processes to augment the accuracy and sophistication of pedagogical agent scaffolding.

Keywords: Pedagogical agent, self-regulated learning, recurrence plot, scaffolding

1. Introduction and Related Work on Pedagogical Agents and ITSs

Proficient learners can autonomously engage with instructional materials by deploying self-regulated learning (SRL) processes such as defining tasks, using cognitive and metacognitive SRL strategies during the learning task, reflecting on their progress, identifying goals, setting plans to achieve those goals, and modifying goals, plans, and strategies (Poitras & Lajoie, 2014; Winne, 2018). SRL processes are essential for effective learning of complex topics and are especially critical for environments that are open-ended and do not provide instructional scaffolding (Azevedo et al., 2022). However, learners are typically unable to demonstrate accurate and effective deployment of SRL processes during learning, possibly due to lack of metacognitive knowledge, thereby resulting in increased cognitive load and decreased learning gains (Azevedo et al., 2018; Josephsen, 2017; Paans et al., 2019; Taub & Azevedo, 2019). Because of this, advanced learning environments, such as intelligent tutoring systems (ITSs), provide instructional scaffolds in the form of pedagogical agents to detect, track, and foster learners' SRL processes. We argue that the accuracy and sophistication of pedagogical agents' individualized scaffolding and feedback can be significantly enhanced through visualizing and quantifying recurrence based on individual learners' enactment of SRL processes.

In a systematic literature review by Martha and Santoso (2019), pedagogical agents within ITSs were touted as useful for increasing domain knowledge and changing learner behavior, including SRL strategies and affect, through hinting, prompting, and providing feedback to learners. However, most pedagogical agents integrated with ITSs are rigidly programmed to follow a linear set of production rules based on temporal and frequency inputs (Webber & Marwan, 2015). In consequence, pedagogical agents do not monitor the degree to which learners' deployment of SRL strategies demonstrates a dynamical relationship and thus does not intervene to scaffold functional SRL processes. This paper sets a rationale for using a nonlinear dynamical systems theory tool to detect, quantify, and visualize learners' changes and transitions of SRL behavior. In proposing this novel technique, this paper provides groundwork for pedagogical agents as interpreters of complex learner visualizations to scaffold SRL during learning with an ITS.

ITSs are computerized instructional systems containing multimodal materials (e.g., video, text, diagram) that provide real-time adaptive instruction to learners (Graesser et al., 2018). ITSs embed a level of intelligence dispersed between several models including a knowledge or expert model, learner model containing information about how the learner exhibits learning behaviors, pedagogical model containing the different strategies of tutoring or teaching, and interface or communication model (Sottilare et al., 2018). ITSs include a level of adaptivity which allows for information obtained from an evolving learner model to be compared against pre-determined desired behaviors for identification of discrepancies between learner and expert models (Mousavinasab et al., 2018). Learner models are comparable to the concept of physical DNA such that these models track and store qualitative and quantitative information representing learner characteristics and knowledge (Akkila et al., 2019). Consequentially, learner models must constantly self-update information due to the dynamic nature of learner behavior, i.e., changing over time, and interaction as learners' new knowledge emerges, relationships between concepts are made, and SRL skills are developed. These learner models are the foundation for the adaptivity displayed within effective ITSs that can emulate and simulate human tutor behaviors in providing individualized tutoring in the form of prompts and feedback to a learner via pedagogical agents (Kim & Baylor, 2016; Johnson & Lester, 2018).

Pedagogical agents are artificially intelligent virtual characters within ITSs that provide some level of instructional, cognitive, or affective support, simulating and mimicking physical tutor-learner interactions (Hooshyar et al., 2015; Johnson & Lester, 2018). Several ITSs throughout education literature have used pedagogical agents to provide information to the learner, prompt the learner to engage in learning or SRL processes, monitor learners' interactions, and provide just-in-time feedback to scaffold learning with an ITS (Velestianos & Russell, 2014). One notable example of an ITS is MetaTutor, a hypermedia based ITS for improving knowledge about the human circulatory system (see Azevedo et al., 2022). This ITS contains several pedagogical agents that prompt learners to engage in different SRL processes. The way in which the pedagogical agents of MetaTutor interact and dialogue with learners is grounded in a series of production rules that are both time- and frequency-based. For example, if a learner has not deployed a content evaluation after a certain number of minutes, a pedagogical agent prompts the learner to engage in this strategy via dialogue. The logic behind the artificially intelligent decisions made by pedagogical agents throughout ITSs to intervene, foster, or prompt learners to engage in certain behaviors during learning most commonly use action-condition rule-based reasoning (Mousavinasab et al., 2018). However, a few limitations of pedagogical agents arise regarding: (1) the extent to which pedagogical agents can be considered beneficial for learning; and (2) the "intelligence" of the pedagogical agents in their adaptive capabilities.

2. Limitations of Pedagogical Agents

While the benefits of pedagogical agents have been extensively researched within educational literature for the support of learning and cognitive processes (Azevedo et al., 2016, 2018; Castro-Alonso et al., 2021; Hidayah et al., 2019), studies have not conclusively identified the effectiveness of pedagogical agents. While some studies support the need for pedagogical agents as scaffolders of learning outcomes (Bouchet et al., 2016; Davis, 2018; Dever et al., 2022; Harley et al., 2017; Schroeder et al., 2013; Wiedbusch et al., 2021), other studies conclude that pedagogical agents do not significantly contribute to greater learning outcomes or increased use of SRL processes (Castro-Alonso et al., 2021; Schroeder et al., 2017; Yilmaz & Yilmaz, 2020). The current paper argues that the lack of cohesive findings regarding the usefulness of pedagogical agents as scaffolds for SRL stem from underdeveloped learner models used by pedagogical agents for detecting, tracking, analyzing, and responding to learners' deployment of SRL strategies while learning with an ITS.

While ITSs are intended to provide instructional tutoring and personalization as learners engage with materials throughout the environment and deploy SRL processes (Hooshyar et al., 2015), pedagogical agents currently do not demonstrate intelligent behaviors needed to provide effective, timely, and adaptive individualized scaffolding for significantly increasing learning outcomes (SchezSobrino et al., 2020). As learner behavior is dynamic, i.e., changing over time, developing an ITS which intelligently and constantly updates learner models and provides adaptive instructional feedback is difficult to achieve (Bouchet et al., 2016; Holstein et al., 2018). The majority of ITSs employ pedagogical agents that interact with the learner model on a predetermined set of actions and rules which assumes that the conditions for a specific prompt are uniform across all learners regardless of SRL skills, metacognitive knowledge, domain understanding, motivation, demographics, etc. This limits the intelligence of systems and defies the dynamic, nonlinear nature of SRL.

To counteract these limitations of pedagogical agents, a new approach to informing and updating learner models that acknowledges the nonlinear dynamics of SRL processes and both qualitatively and quantitatively informs pedagogical agents embedded in ITSs is required (e.g., Li et. al., 2022). We outline and demonstrate a new statistical and visual technique in the field of SRL and ITSs that allows for the evaluation of dynamically changing SRL behaviors to be more accurately and comprehensively updated in learner models to improve how and when pedagogical agents prompt learners to engage in SRL processes during learning.

3. Recurrence Plots as Visualizations of SRL Behavior

Complexity science incorporates nonlinear dynamical systems theory (NDST) which states that small changes in behavior can have a large, nonlinear shift in future behavior (Amon et al., 2019). Recurrence Quantification Analysis (RQA) is an NDST analytical technique for measuring and visualizing the degree to which complex systems, or SRL behavior in our paper, demonstrate chaotic and stable patterns of behavior over time (Vrzakova et al., 2019). Recurrence plots are graphical visualizations of couplings between system components across all time points within each component's time series that can reveal the changes and transitions in system dynamics (Webber & Marwan, 2015). In other words, a recurrence plot identifies each time at which a specific state recurs between two time-identical (i.e., auto-RQA) or time-different (i.e., cross-RQA, multidimensional-RQA) time series. Within this paper, we describe categorical auto-RQA (i.e., aRQA; see Dale & Spivey, 2005) recurrence and provide a preliminary example of how these visualizations can be used to describe SRL in ITSs.

Recurrence plots are structured in a two-dimensional matrix format with the time series on both the X and Y axes. At the intersection of the X and Y axis within the matrix, a solid black dot is placed should the SRL behavior the learner engages in on the X axis recur with the SRL behavior on the Y axis whereas intersections where behaviors do not recur are kept white (Zou et al., 2019). The plot holds a solid black diagonal line from the bottom left of the plot to the top right called the line of identity. The line of identity represents the time at which the time series recurs with itself where Time 1 on the X axis is compared with Time 1 on the Y axis. While the researcher should be aware of this line, the recurrence of a state is not of interest when it recurs with itself as it does not reveal relationships across time (Webber & Marwan, 2015). It is important to note that a recurrence indicator at time intersection (i, j) does not contain information that can be generalized throughout the entire system across time; rather, it is the culmination of all recurrence points that produce interpretable structural patterns that should be considered to diagnose the dynamics of a system. The structure of recurrent points across the plot can indicate if the overall processes of a system are stationary, nonstationary, cyclic, deterministic (i.e., stable), or chaotic. For example, should there be several long diagonal lines that are parallel to the line of identity on a recurrence plot, the system can be described as more deterministic than a recurrence plot displaying several shorter diagonals (Webber & Marwan, 2015). Stationary systems are visualized by the equal dispersion of recurring patterns across a plot whereas nonstationary systems display fading or darkening areas within the recurrence plot (Webber & Marwan, 2015).

While studies across various disciplines (e.g., Sujith & Unni, 2021; Vrzakova et al., 2019) have utilized recurrence plots to visualize complex systems, very few studies have examined how recurrence plots can visualize learner interactions with an ITS (see Allen et al., 2017; Li et al., 2022). Several advantages exist in utilizing recurrence plots to drive pedagogical agents' instructional interventions as learners engage with materials throughout an ITS. First, several types of data can be applied to this statistical technique. This includes both categorical and continuous data that is outputted from data sources including log files, eye tracking, concurrent verbalizations, written answers, etc. As such, recurrence plots can be used across a variety of contexts and domains while adhering to restrictions that may occur in natural environments (e.g., log files collected in classrooms; Dale & Spivey, 2005). Second, recurrence plots can exist in parallel with noisy, unstructured environments that typically contest the assumptions of typically powerful linear analytical tools (Vrzakova et al., 2019; Webber & Marwan, 2015). As SRL processes are complex systems, the method in which learners deploy SRL should be analyzed and interpreted as such. In using RQA and recurrence plots as visualizations of SRL processes researchers, and by extension pedagogical agents in ITSs, can methodologically and analytically respect the complexity of SRL. Finally, recurrence plots can be utilized to both qualitatively *and* quantitatively examine the characteristics of learners' SRL. In addition to the qualitative topographies and patterns that can be extracted from recurrence plot visualizations to provide information as to the temporal dynamics of a system, quantitative statistical measures can be extracted from the organization and frequency of the black indicators of recurrent patterns. These metrics extracted from recurrence plots have the potential for describing learners' SRL without diluting the rich data that can be extracted from their interactions with the ITS (Li et al., 2022). At the crux of these advantages exists the question of how recurrence plots can be used by ITSs to update the learner model to improve pedagogical agent scaffolding of SRL.

For this paper, we extracted a representative participant from a sample of undergraduate students who learned about the human circulatory system with an ITS, MetaTutor, while receiving prompts from pedagogical agents to deploy SRL strategies. The participant extracted had a minimum of ten SRL events and demonstrated the lowest learning gains out of the entire sample of participants receiving scaffolding. This participant's recurrence plot over time visually displays a noticeable shift in the recurrence of deployed SRL strategies. Specifically, the participant shifts from displaying functional SRL behaviors (Figure 1A.) to dysfunctional (Figure 1B.). While towards the end of their session the participant displays functional SRL behaviors (Figure 1C.), the participant was unable to recover as exhibited by their low learning gains. The method in which this participant's data was extracted and visually examined serves as the first exploration into interpreting visualizations of the dynamics of learners' SRL use to transform the traditional learner model and enhance pedagogical agent scaffolding.

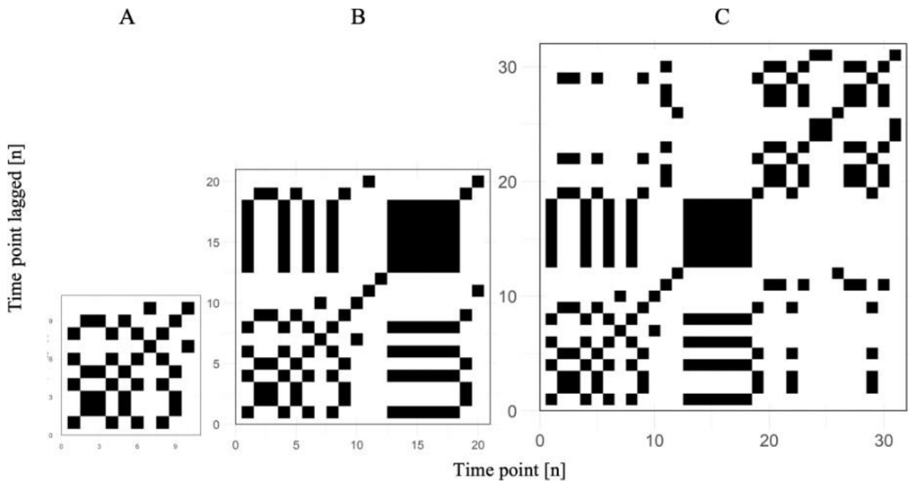

Figure 1. Recurrence plot changing over time as learners engage in SRL processes.

4. Future Directions in Pedagogical Agent Research and Development

The use of recurrence plots, specifically their interpretation, within SRL and ITS research will vary depending on the learning outcomes, measures, and processes of interest. Past studies have found mixed findings regarding what constitutes as "desirable" SRL behaviors exhibited by students. Dever et al. (2022) found that a recurrence plot with a homogeneous distribution of recurrent and nonrecurrent patterns of SRL behaviors scaffolded by pedagogical agents during learning about the human circulatory system are indicative of healthy deployment of SRL strategies. Meanwhile, more recurrent behaviors in the study by Li et al. (2022) described in the previous section are indicators of high performance while diagnosing a virtual patient. In consequence, future directions in research should research and understand the balance needed between chaotic and stable states to produce greater learning outcomes. From this, researchers will be better able to inform how and when pedagogical agents should intervene to provide scaffolding to learners while deploying SRL processes in an ITS.

Merging recurrence plots from RQA and the field of SRL will allow learner models to be updated with information regarding the functional use of SRL processes as learners engage with instructional materials within an ITS. By updating learner models with this type of information and data only accessible through RQA (and by extension recurrence plots) pedagogical agents would be able to identify a correct point in time in which to provide scaffolding to learners. As recurrence plots divulge information about the dynamics of a complex system, future pedagogical agents can provide scaffolding that is more geared towards fostering functional dynamics rather than depending on temporal and frequency data pervading learner models today.

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Pedagogical Companions to Support Teachers' Interpretation of Students' Engagement from Multimodal Learning Analytics Dashboards

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Abstract: Teaching demands educators adapt and improvise their instruction for each student's unique needs and capabilities across contexts. This requires teachers to observe their students, evaluate their ongoing learning, and offer individualized scaffolding and feedback and foster sustained growth and development. This challenging practice has been made even more difficult by the recent emphasis on data-driven instructional decision making from dashboards, further requiring teachers to become both pedagogical and data experts. Despite the development of dashboards to alleviate some of the load of collecting and aggregating complex multimodal student data, there is a need to provide support for teachers in analyzing, interpreting, and applying their students' real-time multimodal learning analytical data (e.g., metacognitive accuracy, negative emotions) in the form of pedagogical companions. Before we can begin the design and development of these agents, we must first understand how educators are currently approaching multimodal learning analytics (MMLA) that report on more than just performance-based outcomes. In this on-going work, we begin by briefly reviewing MMLA in teacher dashboards, teacher data literacy, and the role of pedagogical companions in teacher augmentation technologies. We then describe the development of an in-progress study exploring how three teachers currently use fictious MMLA on self-regulated learning (SRL) processes and the emerging trends we see from their data. Finally, we postulate what these results suggest about the needs that embedded intelligent pedagogical companions may fill in future dashboard and agent design.

Keywords: Multimodal learning analytics, teacher dashboards, agent design, pedagogical companion

1. Introduction

Teaching demands that educators continuously adapt to students' unique individual needs and capabilities, observe their students, evaluate the quality of learning, and offer support they believe would benefit each student while simultaneously improvising within the contextual constraints (e.g., time left in class) and affordances (e.g., instructional resources) of the dynamic classroom environment (An et al., 2020). This tremendous challenge has become more difficult by the recent emphasis for teachers to make data-driven instructional choices based on student achievement and learning progress data (Cowie & Cooper, 2016). However, pre-service teachers have repeatedly reported a lack of efficacy and foundational knowledge associated with data-driven decision-making (Dunlap & Piro, 2016).

In response to the need to augment and complement teaching and data-driven decision-making in the classroom, we have seen the development of many diverse technologies, including learning analytic dashboards (An et al., 2020). However, many of these technologies provide educators with data that are (1) focused on performance versus process; (2) unimodal versus multimodal; and (3) rely on teachers' data literacy skills. This provides a unique opportunity to embed pedagogical companions within dashboards to help teachers understand data and answer questions about evidence-based practices. However, before we can begin the design and development of these pedagogical companions, we must first understand how educators currently approach multimodal learning analytics (MMLA) that report on data beyond performance-based outcomes.

In our on-going work, we begin by briefly reviewing multimodal learning analytics (MMLA) and their role in teacher dashboards, the impact of teacher data literacy, and the role of pedagogical agents in teacher augmentation technologies. We then describe an in-progress study exploring how teachers currently use fictious MMLA on self-regulated learning processes and the emerging trends we see from the small data set collected from three teachers. Finally, we postulate what our preliminary findings suggest about the roles of embedded pedagogical companions in future dashboard design.

2. Related Works

Multimodal learning analytics (MMLA) is an approach for processing multimodal data (MMD) in educational settings to afford a holistic view of students' learning processes (Chango et al., 2022; Sharma & Giannakos, 2020). MMLA was developed out of the need to address limitations in existing approaches' (e.g., educational data mining) overreliance on single-channel data (Chango et al., 2022; Noroozi et al., 2020), and to address calls for increased efforts to triangulate constructs of interest using multiple channels of data. These data can include log files, eye-tracking data, audio recordings, physiological data (e.g., skin conductance), etc. (Liu et al., 2019; Noroozi et al., 2020). MMLA applications must incorporate a diverse range of data channels representative of multiple aspects of learning (cognitive, behavioral, and affective; including emotional and motivational dimensions), and focus on the interpretation of MMLA by teachers to provide meaningful information for teachers.

Teacher MMLA dashboards are defined as user interfaces which aggregate visual information and visualizations about students, learning processes, and/or learning contexts through the organization and visualization of data while including descriptive or predictive analyses to inform pedagogical decisions (Schwendimann et al., 2017). Dashboards can provide insight into students' engagement, behaviors, choices, patterns, and interests—individually or collectively—for use by the teacher to reflect on their instructional decisions (Caspari-Sadeghi, 2022; Verbert, et. al, 2014). Dashboards typically consist of three layers: (1) raw data, (2) artifacts of analysis (e.g., data tables), and (3) presentation (e.g., visualizations; Olshannikova et al., 2015). Gaps in educational literature exist with respect to which types of data and visualizations are most suitable for teachers, particularly in context of data literacy (An et al., 2020; Schwendimann et al., 2017). As discussed by An et al. (2020), dashboards differ in their main focus, from designing data to be quickly interpretable to displaying information publicly within the classroom, to presenting information privately to the teacher. There remains a dearth of design guidance for MMLA dashboards as a result of this incohesive research examining teachers' use of these different visualization strategies. We argue that the gap in literature and lack of success in incorporating MMLA into teacher dashboards stems from the educational fields' lack of understanding of how to properly support teachers' data literacy for the use of MMLA for instructional decision-making.

Data literacy refers to the understanding of presented data for decision-making (Mandinach et al., 2013). Teachers are limited in their understanding of modern data gathering methods and data visualizations which negatively impacts how MMLA can be used to support teacher instruction and subsequently learners' education (Holstein et al., 2019). To address this limitation, further development of standardized objective measures of data literacy is needed where teachers' data literacy competencies need to be more thoroughly understood to support MMLA use (Bonikowska et al., 2019). While teachers and students should be included in the collaborative design of learning tools, these populations' understanding of modern data collection and visualization methods may be limited (Holstein et al., 2019). Designers should consider including pedagogical companions within MMLA dashboards to support teachers' data literacy and data-driven decision-making.

Previous work has explored the role of pedagogical agents in intelligent tutoring systems as teaching assistants (Yacef, 2002), human-agent teaming (Bruni et al., 2019), function allocation (Feigh & Pritchett, 2014), and human-AI complementarity (Holstein et al., 2019). However, a very limited scope of literature has addressed the intersection of these developments to *investigate the design and use of pedagogical agents to support teachers' interpretation of data visualizations of student's engagement data shown using dashboards*. When agents have been combined with dashboards, they have tended to be implemented as background intelligence within decision-support systems or chatbots (e.g., Mekni, 2021). Thus, our current work seeks to extend this prior research on pedagogical agents through an analysis of their use within MMLA dashboards to support teachers' interpretation of and decision-making based on MMLA (i.e., as a pedagogical *companion*).

3. Current Study

The aim of this study is to understand how teachers use MMLA dashboards that display performance and self-regulated learning data about their classrooms without any prior training to assess data literacy and the type of scaffolding that pedagogical companions should provide. Previous research suggests that despite the emphasis of using data to make instructional decisions, current dashboards focus on unimodal performance data. While newer dashboards have incorporated process data, there is still much to be understood in how teachers interact and use such data. In order to address the current gaps, we propose the following research questions:

1. *What type of data and how long do teachers consult in the dashboard prototype environment to assess student engagement? Is this different between types of instruction and engagement?*
2. *What are some of the concerns or questions teachers raise about the data, visualizations, or dashboard?*

Given the research briefly reviewed above, we hypothesize that we will see many trials having the longest total page time duration performance data. Additionally, we hypothesize that teachers will have questions about data and visualizations that contradict one another, how to interpret physiological data, and how to interpret data visualizations that are unfamiliar to them.

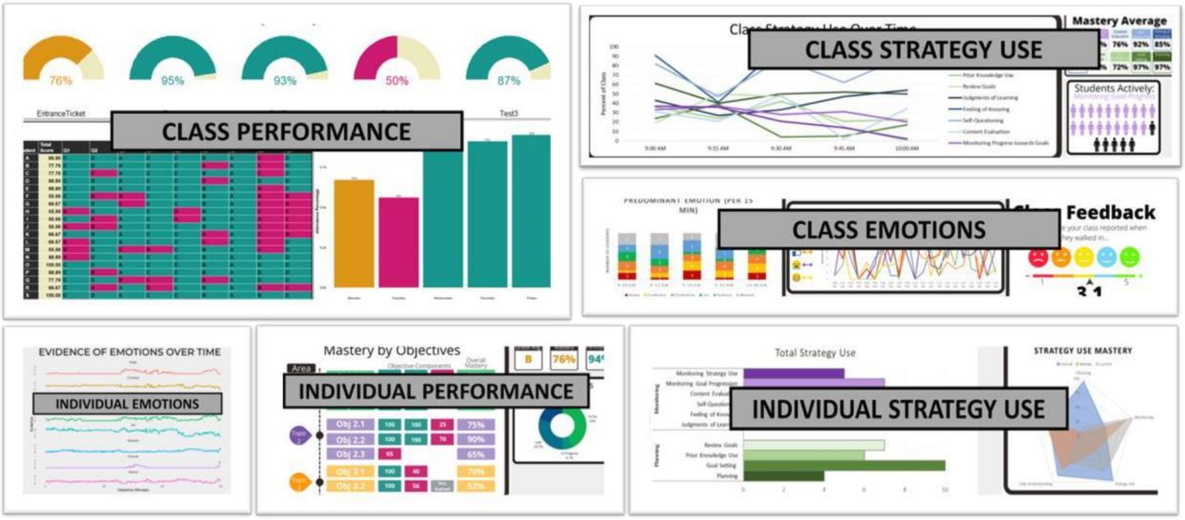
4. Methodology

We are conducting a 2 x 5 within-subjects study (instructional format x engagement type) to examine the relationship between Instructional Format (Online or Classroom) and Engagement Type (Cognitive, Behavioral, Emotional, Agentic, or All) on in-service and pre-service teachers' interpretation of student engagement. Participants (N = 3; 1 in-service, 2 pre-service) follow a think-aloud protocol while examining fictitious students' level of engagement and expressing their own instructional decision making across 10 trials within the MetaDash prototype environment (Wiedbusch et al., 2021). Participants complete a demographic, teaching experience, and data use pretest, think-aloud training, and environment training before beginning the experiment.

During each trial of the experiment, participants are shown a scenario page, containing a scenario description, contextual image, navigation grid for data pages, and button for proceeding to the next scenario. The scenario description provided at the top of the screen included one of 10 single-sentence textual vignettes of a teacher's observations of two students ("Student A", "Student B"), followed by the question *"How would you interpret each student's level of engagement and learning? Please explain. If you were to make any instructional changes at this moment, what would they be and why?"*. The contextual image provided at the left-side of the screen provided a small image contextualizing the scenario but not displaying any relevant information. The navigation grid provided on the right-side of the screen displayed graphic buttons navigating the participant to new pages within the environment each displaying different data visualizations, organized as a 3 (source of data; performance, strategy use, and emotions) x 3 (data subject; Student 1, Student 2, and Class) grid. The types of data and visualizations that were displayed are detailed in Figure 1. All data were randomly generated but consistent across participants, with no intentional diegetic relevance or other visual pattern corresponding to the scenario. From the main scenario page, participants were directed to click the buttons of the navigation grid and to navigate to any of the subordinate pages in any order and as frequently as they would like. Participants were asked to think-aloud while viewing the information on the main scenario page and subordinate pages of fictitious students' data and to answer the target question provided in the scenario description, before proceeding to the next scenario. Once participants completed all 10 trials, they were asked to complete a posttest on their opinions on data use. The experiment took about 1.5 hours to complete. At the end of the experiment, all participants were debriefed, thanked for their participation, and compensated.

Figure 1:

Data visualization examples of student engagement and performance data



5. Initial Findings

Given our limited data size, we are unable to report any statistical testing but instead report descriptive statistics (frequency and average time in mm:ss each participant spent looking at data pages for classroom scenarios) and can examine trends that begin to emerge. for all classroom trials in Table 1. Due to brevity, we do not examine the student types (high/low engagement and class) levels, nor context (online versus classroom), but will extend our analysis to these factors in future analysis.

Table 1. *Frequency and Average Time for Trials Based on Engagement type and Data type*

Engagement Type	Data Type	Participant 001		Participant 002		Participant 003	
		Count	Time (mm:ss)	Count	Time (mm:ss)	Count	Time (mm:ss)
Agentic	Cognitive	1	2:46	3	2:53	4	6:52
	Emotion	1	1:34	3	3:35	3	7:30
	Performance	3	3:46	3	3:00	4	7:49
Behavioral	Cognitive	0	-	2	4:00	3	2:50
	Emotion	1	1:57	3	1:36	1	3:11
	Performance	2	5:41	5	2:53	3	3:14
Cognitive	Cognitive	1	3:07	4	2:01	4	2:54
	Emotion	2	3:17	3	7:40	3	5:16
	Performance	2	4:35	3	5:44	2	4:13
Emotional	Cognitive	0	-	4	2:47	4	6:14
	Emotion	4	2:43	3	2:19	3	2:08
	Performance	3	3:33	5	6:23	5	2:16
All	Cognitive	0	-	2	2:15	2	5:14
	Emotion	2	2:54	3	2:24	3	2:39
	Performance	2	1:25	3	2:20	3	4:13

There are some patterns that have already emerged from this data. First, most participants spend an average of 3:53 minutes on each data page across trials, but we see individual differences. Additionally, we see similar individual differences in how often participants visited each data page. This suggests just as there is not a one-size-fits-all approach to teaching students, teachers have unique approaches to data use and the type of data literacy support needed should be adaptive and individualized. Table 1 also shows the length and frequency of the type of data that teachers visit does not seem to be affected by the engagement type of the scenario provided. This is surprising as one would expect when faced with a scenario describing cognitive engagement, teachers might spend more time focused on the cognitive data. We do note that there is one potential exception for emotion-engagement scenarios, but more data is needed. Our preliminary findings indicate teachers are either unaware of the type of data they should be consulting based on the limited scenario descriptions, or that they are consciously choosing to approach the data in similar ways across all scenario types. Finally, teachers appear to be visiting and spending more time examining the performance data pages compared to cognitive and emotion data pages. This is unsurprising as the data that they are most familiar with or expected to currently use in their instruction is performance and grade based MMLA.

To address our last research question, we examined participants' think-aloud transcripts. While we have not finished development of a coding scheme, some interesting themes are beginning to emerge that may help future analysis. For example, we expected teachers to raise more questions about data that seemed to contradict one another within a trial. While some participants did recognize they did not make sense, *"That's odd… I don't know how a student with a 97% grade average ... 96%... a high A or whatever is feeling confused so much,"* (quote from Participant 2), they did not question the quality of the data. That is, teachers treated the data as objective infallible truth, a fact that MMLA researchers know is a dangerous assumption. Additionally, the think-aloud transcripts reveal that our participants seem to be primarily using top-down approaches to data use. That is, they are interpreting the scenarios prior to examining any data and then looking for data to support their findings. Participant 3 highlights this when she spent over 5 minutes explaining how one particular trial was *"definitely a behavioral issue. I see this all the time, and a lot really recently. This is 100% behavioral… something going on at home. Or another class. This is a behavior issue. [sigh] I mean some kids just have an attitude and you have to roll with it."* This conclusion was drawn before any data was examined, suggesting that educators may be using MMLA dashboards to provide administrators or other stakeholders with evidence of their conclusions, but not drawing conclusions from the data at all.

6. Preliminary Implications for Artificial Companions and Teacher Dashboards

Our ongoing data collection will continue to provide a very rich data set for which we can continue to explore some of the analyses in this paper as well as expand to future analysis. These analyses will help us in the future design and development of pedagogical companions to support teachers in their data-driven instructional decision making. Preliminary results suggest that teachers do not consider the context before determining what data to consult. We envision a pedagogical companion that makes suggestions about the most appropriate data for use. Alternatively, this companion may also metacognitively prompt a teacher to reflect on what type of data they would ideally like to consult and why before analytics are available. The teacher may have to justify why certain data is appropriate for making an instructional decision. By introducing conversational natural language processing into this system, even if an educator does not have strong data literacy, they could describe what it is they think they are observing and ask the companion to provide data about their subjective views. For example, if a teacher believes a student is getting frustrated and that is why they are disengaging with the lesson, they could tell the companion and ask for emotional state data about that student. We can imagine the companion then providing historical data about how the student typically feels during a lesson, how they feel when they struggle, and how they are currently feeling. This does not require that a teacher necessarily understand what type of data they need, but rather they are provided with relevant information from the pedagogical companion as they describe what they are observing. However, we must be careful to mitigate data cherry picking. Our preliminary results suggest that teachers rely on top-down approaches to using MMLA. As such, future pedagogical companions should be able to scaffold bottom-up, or data-driven, approaches to interpreting student engagement by focusing educators' attention to critical data as it occurs. For example, we can imagine the companion alerting the teacher to high frequencies of negative feelings-of-knowing metacognitive judgements. Even if the teacher was not originally aware that the class was not confident in their understanding of the topic, the companion could provide visualizations of judgement frequency distributions, problem attempts, and facial expressions of confusion. This helps address the detection of engagement, but we must also consider how to support teachers' application of this data for instructional decision making. Ideally, the teacher could ask their pedagogical companion if they apply a certain instructional strategy, what the data would then look like. In response, the companion would then provide a predictive simulation of future data, or even a comparison of multiple strategy outcomes for the teacher to then choose from.

Through our future work, we will address the challenge of providing teachers support as they use MMLA with a greater diversity of channel combinations to better represent complex learning phenomenon in their dynamical interpretation of student engagement and learning. As this work continues, we will make actionable and clear suggestions of what best practices and considerations should be made based on how teachers are currently using MMLA data without any support.

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Towards a Humorous and Empathetic Companion Dialogue System with a Cultural Persona for Older Adults

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Abstract: Artificial Intelligent (AI) dialogue systems have been used as companions to provide daily social support and promote healthy lifestyles for older adults. Existing studies on empathetic companionship of AI dialogue systems found that these dialogue systems have primarily focused on passive observation of scenarios and computational simulation of companionship. In addition, these dialogue systems are unable to provide tangible empathetic and humorous companionship through meaningful and purposeful involvement to alleviate loneliness of older adults while considering their cultural backgrounds. In this research-in progress paper, we propose a companion dialogue system with an empathetic and humorous persona to actively collaborate with older adults to help curtail loneliness by resolving a task together while considering the user's cultural backgrounds. The companion dialogue system will be capable of offering personalized therapeutic intervention based on behavior modification models, fostering emotional empathy and intermediate humor via culturally rich conversational exchanges, and reducing loneliness and depression through activities that involve team cooperation.

Keywords: Artificial Intelligent, older adults, humor, empathy, culture, persona

1 Introduction

The percentage of the population that is aged 65 and older is expected to skyrocket over the next decades, rising from 17.4% in 2014 to 25.6% in 2030 (Kamali et al., 2018). Numerous elderly individuals live alone, and the experience of isolation might aggravate some of the medical ailments they already have. Despite the fact that nurses and other caregivers often fill in for absent family members, these alternatives are becoming more restricted as demand exceeds the supply. As a result of advancements in artificial intelligence (AI), it is now possible to build therapeutic interactions not just with humans but also with artificial entities, which are often referred to as social dialogue systems or dialogue systems. AI dialogue systems are software agents that allow users to access services and information via interaction in the users' everyday language, whether that engagement takes place through text or speech. These dialogue systems are able to speak with older adults in an empathic and humorous manner and often have become companions (Shum et al., 2018; Takahashi, 2019).

These existing companion dialogue systems for older adults, however, are only capable of addressing a provocation of empathy from passive observation instead of active involvement to better mental health, to cognitive function, and most importantly to avoid social isolation. Due to the unfamiliarity with the complicated technology, the interaction between companion dialogue systems and older adults seems rather mechanical, patronizing, and lacks humor (Takahashi, 2019). In addition, none of the existing studies have focused on older adults' cultural heritage when designing a companion dialogue system, and cultural heritage can improve older adults' health and well-being by igniting their memories and imaginations.

Therefore, this paper proposes a companion dialogue system with an empathetic and humorous persona to actively engage with older adults to resolve a task, such as Trivia Quizzes, Puzzles or Sudoku, by deciding together while considering their cultural backgrounds. By doing so, the dialogue system attempts to curtail loneliness by offering personalized therapeutic intervention based on behavior modification models and fostering empathy and humor via emotionally and culturally rich conversational exchanges.

2 Related Work

Many studies have been conducted in finding ways to mitigate older adults' loneliness and social anxiety (Razavi et al., 2019; Shum et al., 2018; Takahashi, 2019). These studies can be generally classified into four types of AI dialogue systems embedded with humor, empathy, culture, and persona. The AI humor system is primarily employed to imitate the style of human interaction to mitigate frustration when engaging in a conversation with a computer (Shum et al., 2018). The AI empathetic system has been used for analyzing older adults' emotions and generating responses (Li et al., 2022). The AI Culture system has been embedded in the systems to indicate society's shared ideas and make contributions to society (Takahashi, 2019). A persona-based dialogue system is a character that aims to mitigate seniors' loneliness, social anxiety, or social isolation (Razavi et al., 2019).

2.1 AI Humor

Humor is an indispensable and pervasive aspect of daily life associated with various positive consequences. It is believed that humor and positive expression of emotion reduce users' anxiety, including seniors, and act as a buffer against stress. Thus, various humorous companion dialogue systems have been introduced to curtail the issues of anxiety and loneliness (Mundhra et al., 2021). In 2014, China launched XiaoIce (literally Little Ice in Chinese), a social companion dialogue system (Shum et al., 2018). The system architecture and main components are highlighted by the core chat computing module. Core Chat is an advanced technology that engages users to participate in extensive and open-domain discussions with other users. Similarly, Replika is a chitchat companion system whose architecture resembles that of Core Chat in XiaoIce. Replika combines neural generation and retrievalbased techniques to condition responses. Replika's neural generating component is persona-based, similar to XiaoIce's neural response generator. Replika is believed to contribute to higher self-esteem by reducing loneliness and introducing optimism and humor if it is used to motivate individuals to reach out to others with more confidence and vigor (Takahashi, 2019).

2.2 AI Empathy

Empathy is the capacity to place oneself in another's position and make an informed judgment. As individuals age, they become more fragile, and their demands increase. Companion dialogue systems have been proven efficient in addressing social isolation and loneliness in older adults by offering empathetic responses. Zorrilla et al. (2018) proposed an empathetic virtual coach for older adults at home, and the authors believed that the virtual coach was able to develop causal models of coach-user interaction to help older adults curtail loneliness, maintain their health status, and enhance their quality of life. Ring et al. (2015) introduced a multimodal conversational agent-based system intended to offer longitudinal social assistance to solitary older adults. Based on the exploratory pilot study, the system has a high degree of acceptability and customer satisfaction. Results showed that it effectively mitigated loneliness when the system actively invited older adults into interactions triggered by a motion sensor. The design of active involvement of the system is in contrast to the existing studies, which often involve companion systems' passive participation depending upon elders to initiate interactions.

2.3 AI Culture

Through the lens of their respective cultures, people identify themselves, conform to society's shared ideals, and make contributions to society (Takahashi, 2019). Cross-cultural studies of companion dialogue systems for older adults are scarce, and only a few studies include cultural elements in the design of dialogue systems, such as Xiaoice and CARESSESS. XiaoIce allows users to build long-term, emotional bonds with one another, and it also takes into account cultural variations and a large number of sensitive ethical concerns (Shum et al., 2018). The author believed that when XiaoIce is embedded onto an open social chatbot platform for third parties, its persona is able to be customized according to the particular user scenarios and cultural norms of the users. Riva and Riva (2019) proposed a companion dialogue system, CARESSES, embedded with culturally competent artificial intelligence. CARESSES was made aware of the particular older adults' cultural backgrounds, and the system employs the appropriate Cultural Knowledge Base (CKB), which is able to predict participants' values and preferences. The results showed that using the CARESSES system is likely to enhance the psychological well-being of older adults.

2.4 AI Persona

A persona dialogue system is a character the system presents to its users. It endows the dialogue system with a personality that distinguishes it from a monotonous conversation (Li et al., 2016). Razavi et al. (2019) proposed an automatically spoken dialogue manager for LISSA, an on-screen virtual agent that can engage in a series of casual discussions with older adults to mitigate seniors' loneliness, social anxiety, or social isolation. LISSA is capable of adapting its behavior to the unique requirements and preferences of individual users. The results showed that older adults found LISSA easy to use and user friendly. Dratsiou et al. (2022) introduced a dialogue system embedded with persona, SHAPES, integrating a wide variety of digital technologies into a healthcare-related technological ecosystem. This system supports the healthy, active, and independent living of older adults. The authors believe that SHAPES has the potential to engage senior citizens in an all-encompassing technological environment and make it easier to preserve a good quality of life.

The existing studies, however, have segregated the important components, such as humor, empathy, culture, and persona, to mitigate the loneliness and social anxiety of older adults. Therefore, this paper proposes a companion dialogue system with an empathetic and humorous persona to actively engage with older adults to resolve a task, such as Trivia Quizzes, Puzzles or Sudoku, by deciding together while considering their cultural heritage. By doing so, the dialogue system attempts to curtail loneliness by offering personalized therapeutic intervention based on behavior modification models and fostering empathy and humor via emotionally and culturally rich conversational exchanges.

3 Discussion

Existing companion systems overlooked the difficulties of humor as older adults find the intermediate level humor the funniest, whereby humor that is either too simple or too complex to grasp is likely to be ignored (Shum et al., 2018). Studies found that older adults scored lower on affiliative humor, which is used to strengthen social relationships and put people at ease by cracking jokes. In addition, existing studies seemed to overlook older adults' cultural backgrounds when designing a companion dialogue system, as these types of cross-sectional research on companion dialogue systems are subject to cohort effects, in which individuals from various generations are impacted by distinctive life experiences, demographic tendencies, and societal conventions (Shum et al., 2018).

Existing companion systems did not specify which types of empathy affect the quality of older adults' life and social integration as most dialogue systems have primarily been used for analyzing older adults' emotions and producing generic responses (Li et al., 2022) rather than actively collaborate with older adults to help mitigate social isolation by participating in meaningful and purposeful activities to increase seniors' positive and uplifting feelings. Older adults might have weaker cognitive empathy (i.e., the ability to comprehend others' ideas and feelings) than younger people but have higher levels of emotional empathy (i.e., the ability to feel emotions that are similar to others) (Li et al., 2022).

These studies have not specified the particular layer of the culture embedded in the companion dialogue systems as people identify themselves, conform to society's shared ideas, and make contributions to society (Takahashi, 2019). According to Haarmann (2007), there are generally five layers of cultural aspects, which embrace (1) signs & symbols, (2) behaviors & institutions, (3) cultural values, (4) belief systems, and (5) worldview. First of all, signs & symbols are referred to as material culture. This includes materials that may be easily observed, such as symbols, tools, architecture, art, and spoken language. Secondly, observable behaviors and the 'institutions', which are subsets of a society's members who share a common goal, such as schools (for education) and hospitals (for health care), as well as shared activities, such as gestures. Thirdly, cultural values (e.g., collectivistic cultural value and individualistic cultural values) drive decision-making and interpersonal behavior. Cultural values give significance to signs and symbols and influence behavior and Institutions. Fourthly, belief systems are convictions that people live by and have a set of core ideas that leads them through life. Lastly, a worldview is a collection of preconceived notions and underlying assumptions that explain the reality of the universe and our existence.

A persona-based dialogue system is a character that engages in a series of casual discussions with older adults to mitigate seniors' loneliness, social anxiety, or social isolation (Razavi et al., 2019). However, existing studies did not delineate what type of persona has been employed in the design of the companion dialogue systems. According to Alduaifi et al. (2020), there are four types of personas, including (1) goal-directed personas, (2) role-based personas, (3) engaging personas, and (4) fictional Personas. The purpose of a goal-directed persona is to investigate the method and workflow that the user would prefer in order to achieve their goals. The role-based views' personas are mainly data-driven and combine both qualitative and quantitative data sources. Engaging personas that are designed to increase user engagement with the system. Fictional personas assess elements such as users' emotions, psychological status, and their backgrounds and make these elements relevant to the task.

4 Research Contribution

The proposed companion dialogue system entails two parts including (1) a knowledge base and (2) a corpus. The knowledge base retains a conversational history as well as a few lines that describe who it is (its persona). The corpus contains three components, such as a cultural model, an emotional empathy model and an intermediate level humor model. When the dialogue system receives a new utterance from a user, it initially will mix the information from this knowledge base with the newly obtained utterance in order to provide a general reply. As the conversation proceeds further, and a game such as Trivia Quizzes, Puzzles or Sudoku will be introduced. During the conversation of the game participation, GPT dialogue system is able to identify the user's social background whether it is collectivistic or individualistic cultural value from user utterance. The dialogue system will concatenate the contextual segments (either with intermediate humor or emotional empathy) into a single sequence. The single sequence then combines the dialogue history to generate a response to mitigate older adults' loneliness and social anxiety by actively involving a collective game session (See Figure 1).

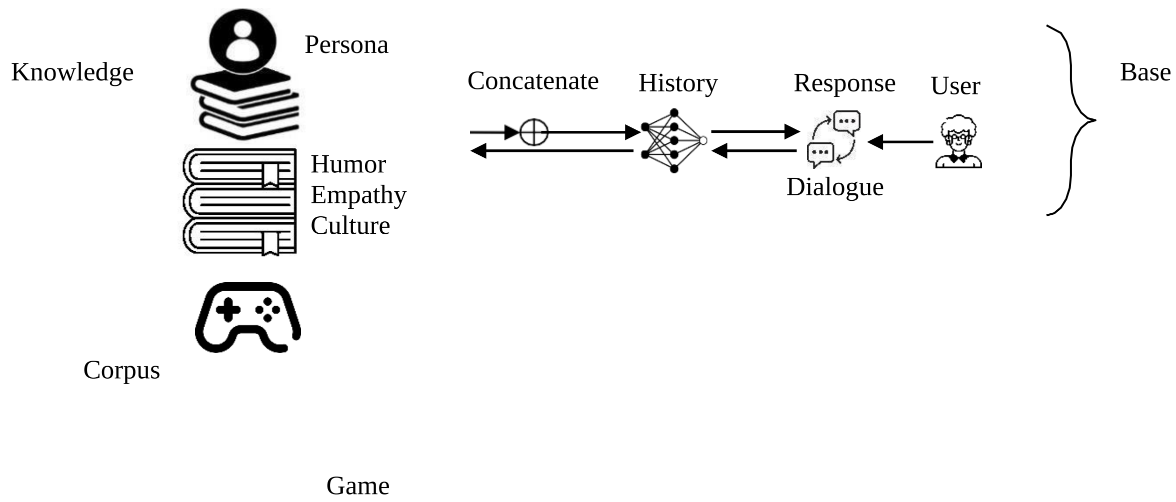

Figure 1. A summary of the GPT companion dialogue system

4.1 Humor Model

This study adopted the humor generator proposed by Akbar et al. (2021), and the generator utilized a comprehensive pre-trained language model generative pre-trained transformer (GPT2). In addition, a humor classifier employs the fine-tuning bidirectional pre-trained encoder (BERT) in order to categorize easy humor, intermediate humor, and complex humor. The humor dataset includes 200,853 news headlines, links, categories, and individual articles (Akbar et al., 2021). The number of characters used in humor ranges from 10 to 200. Each line in the file is associated with a unique ID and humor. The dataset has been compiled into a single.csv file and is downloadable from Kaggle. It is vital to embed Akbar et al.'s (2021) intermediate-level humor generator, which aims to curtail anxiety and loneliness along with empathy and cultural models.

4.2 Empathy Model

This study adopts Muthukumar et al.'s (2021) fine-tuning of the GPT-2 model in order to provide a brief, user-specific empathetic emotional responses. The model employs a sentiment analysis history-based reinforcement learning strategy to respond empathically and individually to users. For the datasets, this study utilized the EmpDG model introduced by Li et al. (2022), which consists of two types of information sources: ConceptNet and the NRC VAD emotional lexicon. ConceptNet is a knowledge graph that employs natural language to represent extensive human knowledge, and it plays a crucial role in sentiment-related activities. It is important to embed Muthukumar et al.'s (2021) fine-tune the GPT-2 model in a companion dialogue system for older adults, as the model focuses explicitly on emotional empathy to mitigate the emotional impact of being socially isolated and speed up emotional recovery from loneliness and social anxiety.

4.3 Culture Model

Drawing inspiration from Liang et al. (2019), this study employed a culture classifier to forecast the culture likelihood. Each dimension was normalized by using a culture-specific z-score to reduce the influence of cultural differences on the pre-processing of the data. This approach is essential because it mitigates the negative effects of culture on multimodal emotion detection. The Wikipedia Cultural Diversity Datasets, which cover more than 300 language versions across 90 territories, were used for the cultural elements (Miquel-Ribé & Laniado, 2019). The data files were compressed into bzip2 and stored in the comma-separated values file (CSV) format to facilitate processing. The English Wikipedia occupies 265 MB of the dataset's 1.67 GB overall size. The importance of Liang et al.'s (2019) model is that it can distinguish senior users' cultural backgrounds, whether they are from collectivistic societies (e.g., tend to experience a high level of loneliness) or individualistic societies (e.g., tend to experience a low level of loneliness). The uniqueness of Liang et al.'s (2019) model is it can decrease the probability of seniors being physically isolated, lack of social engagement by considering various cultural backgrounds.

4.4 Persona Model

This study adopts Nißen et al.'s (2022) MANOVA model, which is specialized in dialogue system persona, and it takes into consideration participant gender and age. There is a statistically significant interplay between persona and age. Older participants reported higher levels of outcomes with the closer peer and dialogue systems. This study uses the PERSONA-CHAT dataset extracted from Amazon Mechanical Turk, in which each pair of speakers conditions their interaction on a predefined profile (Nißen et al., 2022). The importance of Nißen et al.'s (2022) MANOVA model is that it focuses on users' gender and age and is designed to increase user engagement with the system to mitigate seniors' loneliness, social anxiety, or social isolation. These personas assess elements such as users' emotions, psychological status, and backgrounds and make these elements relevant to the task.

5 Proposed System Design and the Pilot Study

The design of the study will be divided into two stages. In this initial step, a prototype for the companion dialogue system will be designed. The second step is the pilot study, which consists of participant recruiting and an interview lasting 30 minutes to assess the viability of the chatbot. A companion dialogue system's initial step of development involves the incorporation of four additional features: intermediate humor and emotional empathy, cultural values, and persona. Older adult participants for the pilot study will be recruited from a local city council in Brisbane, Australia. It is anticipated that a total of twelve participants will be chosen, and the arguments for this sample size are based on logic about the practicability of the endeavor (Julious, 2005). The participants will be provided access to a chatbot for a 14-day intervention as soon as they have agreed to participate in the study and have returned the completed interview permission form and information sheet.

6 Conclusion and Future Work

This research in progress paper proposes a companion dialogue system with an empathetic and humorous persona to actively collaborate with older adults to help curtail loneliness by resolving a task together while considering the user's cultural values. The significance of the companion dialogue system is believed to offer personalized therapeutic intervention based on behavior modification models, foster empathy and humor via emotionally and culturally rich conversational exchanges, and fight loneliness or depression through activities that involve team cooperation.

For future studies, we recommend that research can be done on BERT to improve the detection of emotional empathy, sense of intermediate humor, cultural values, and engaging persona for older adults to mitigate their loneliness and social isolation.

This research has several contributions including (a) an expansion of the existing body of work on a companion dialogue system for older adults with a particular emphasis on culturally relevant humor and empathy algorithms, (b) the identification of the gaps and limitations of companion dialogue system implementation and application; and (c) a recommendation for more research on companion dialogue system that takes into consideration a user's cultural background.

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When Calculus Learning Collides with The Metaverse

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Abstract: Spatial's multiple virtual platforms with interoperable portals, avatars, shared spaces and audio/text messages help teachers enhance the online learning experience and activities for students. In this paper, we propose the following pedagogical strategies using the metaverse: First, using multiple shared-screen modes from Spatial's virtual environment, students use our real time C3 (competition, cooperation, and communication)-based learning platform to learn from each other while solving synthetic (man-made) and real-life first year calculus problems. Second, teachers, students and peers create their own lifelike avatars to interact with each other in different shared spaces. The role of the C3 platform is to act as a teacher-led learning delivery system to build a reciprocal relationship between students and teachers, where students can learn from each other using online cooperation and/or competition learning modes and peers freely walk through different shared spaces to learn how these students solve math problems interactively and see what kinds of mathematical tools and techniques they use. Third, using interoperable portals, based on six designated Calculus problem sets, teachers can simultaneously place different groups of students in different shared spaces according to their teaching pace and have more opportunities to learn about and better understand what students and peers learning needs are. This paper also presents the pedagogical methods, for example, educational game strategies, the initiation/response/evaluation/feedback/follow-up communication pattern, and conceptual and procedural approaches that were used in this work, and finally demonstrates a few worked examples.

Keywords: E-learning platform, mathematical thinking processes, metaverse, questioning types

1. Introduction

Metaverse, the combination of the prefix "meta" (implying transcending) with the word "verse" that is same as "universe," describes a hypothetical synthetic environment linked to the physical world (Joshua (2017)). The metaverse also offers hands-on experience and activities linking the virtual and physical worlds, as well as multiple platforms that benefit students and teachers who can partake in them right from their own homes. There are numerous well-developed metaverse platforms in the commercial market, e.g., Decentraland (https://decentraland.org/), Gather Town (https://www.gather.town/), Virbela (https://www.virbela.com/), Sandbox (https://www.sandbox.game), and Spatial (https://spatial.io/). Typically, Spatial's multiple virtual platforms with interoperable portals, avatars, shared spaces and audio/text messages help teachers enhance the online learning experience and activities for students. In this paper, we propose the following pedagogical strategies for learning Calculus (Hodgen & Wiliam (2006), Ingram (2021)) using the metaverse:

1. Using multiple shared-screen modes from Spatial's virtual environment, students use our real time C3 (competition, cooperation, and communication) based learning platform (Wong & Li (2021)) to learn from each other while solving synthetic and real-life first year calculus problems.
2. Teachers, students and peers create their own lifelike avatars from a selfie to interact with each other in different shared spaces. The role of the C3 platform is to act as a teacher-led learning delivery system to build a reciprocal relationship between students and teachers, where students can learn

from each other using online cooperation and/or competition learning modes and peers freely walk through different shared spaces to learn how these students solve math problems interactively and see what kinds of tools and techniques they use. Through these activities, the peers can learn MATH and freely voice their ideas and problems without any pressure.

3. Using interoperable portals, based on seven designated Calculus problem sets, teachers can simultaneously place different groups of students in different shared spaces according to their teaching pace and have more opportunities to learn about and better understand what students and peers learning needs are.
4. Through the use of audio and text message exchanges and many-to-many, many-to-one, and oneto-one interaction modes, students actively participate in the learning process through talking, asking questions and giving answers.

The rest of the paper is summarized as follows. In Section 2, we describe how an e-learning platform in Calculus using an educational game in the metaverse is created. In Section 3, we explain how we used mathematical thinking processes in the calculus problem design and describe the different questioning types embedded in the platform. The applications of an iterative model of the initiation- response-evaluation/feedback/follow-up sequences in online Calculus teaching and learning are also emphasized. In Section 4, we demonstrate a few examples of how the metaverse and the C3-based learning platform can be used in face-to-face and online teaching. Conclusions and future works are presented in Section 5.

2. C3-based learning platform

Our aim here is to develop a social learning network and sphere using the C3-based learning platform to link the Spatial metaverse. To ensure more measurable competitive and cooperative learning and keep an (turn-taking) activity going, we use educational games. Different simultaneous/sequential games for two students (players) (or two groups of students) from the applications of game theory (see e.g., Straffin (1993)) in strategic thinking are first embedded in the platform. After they play a game, the winner has the first choice of which of the two Calculus problems to solve, that is, a choice between solving the easy or the hard problem. There are six sets of problems addressing first year Calculus topics: limits, continuity and differentiability, differentiation, indefinite integrals, definite integrals, applications of differentiation and integration. For each problem set, we use various types of two person games, for example, the Three Boxes Game (Gardner (1959)), the Spoof Game (Schwartz (1959)), the Odd Even Game (Cohon (1979)), the Bluffing Game (Graham (1997)), the Fibonacci Nim Game (Whinihan (1963)) and Game of Dice (Prisner (2014)). After five problems are solved, the two players play the game again, and the winner gets to choose one of two problems. Every fifth problem they are required to play another game. Detailed descriptions of each two-person game with the rules of the game can be found via the html link: https://www.math.cuhk.edu.hk/~mathcal/mathgame/

3. Mathematical thinking processes in the calculus problem designs

3.1. Questioning types in the platform

Our aim is to use different types of mathematical thinking processes in the calculus problem designs – Mason's (Watson & Mason (1998)), Walsh and Satters's (Walsh & Sattes (2011)), and Sahin and Kulm's (Sahin & Kulm (2008)) questioning types are also embedded in the platform to encourage students to interact and share experience, improve mathematical thinking and orchestrate students' conservations before they respond to the questions.

For example, as proposed by Sahin and Kulm's questioning types (Sahin & Kulm (2008)), we use the criteria shown in Table 1.

Table 1. Criteria for describing the question types

For designing probing questions, we:	For designing guiding questions, we:	For designing factual questions, we:
• Ask students to explain or elaborate on their thinking. • Ask students to use prior knowledge and apply it to a current problem or idea. • Ask students to justify or prove their ideas.	• Ask for a specific answer or ask for the next step of a solution when students are confused or stuck. • Ask students to think about or recall a general heuristic or strategy (Pólya (1947)). • Ask a sequence of factual questions that provides ideas or hints that scaffold or lead toward understanding a concept or completing a procedure.	• Ask students for a specific fact or definition (Vacc (1993)). • Ask students for an answer to an exercise. • Ask students to provide the next step in a procedure.

As shown in Figure 1, the questions we construct sometimes involve the intersection of two or even three different question types, i.e.,

- Probing and Guiding Questions (in purple)
- Guiding and Factual Questions (in green)
- Factual and Probing Questions (in orange)
- Probing and Guiding and Factual Questions (in pink)

For example, when solving each problem, students are required to solve a few sub-problems that may contain any combination of these question types. Details on each questioning type model with their criteria can be found via the html link: https://www.math.cuhk.edu.hk/~mathcal/mathgame/

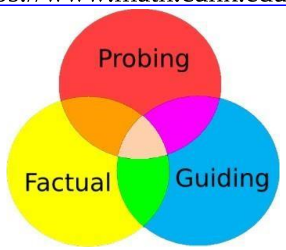

Figure 1. Venn diagram for the combination of question types.

3.2. An iterative model of the initiation-response-evaluation/feedback/follow-up sequences in online Calculus teaching and learning

In order to help students develop higher order thinking skills via the platform, we use an iterative model of the student-teacher-student communication interaction pattern sequences in online Calculus teaching and learning.

In terms of an iterative model, students are allowed/encouraged to revisit the same problem set whenever they like. In terms of a student-teacher-student communication pattern (see e.g., Sinclair & Coulthard (1975), Swann et. al. (2004), Walsh (2011), Ingram (2021)), we have a two-move sequence, i.e., Initiation-Response (IR) (see e.g., Mehan (1979)) or three-move sequences, i.e., Initiation-Response-Evaluation/Feedback (IRE/IRF) (see e.g., Rustandi & Mubarok (2017)) and Initiation-Response-Follow-up (IRFo) (see e.g., Miao & Heining-Boynton (2011), Park et. al. (2020)). Table 2 summarizes these two types of move sequences.

Table 2. *List of communication interaction patterns*

Communication Interaction Mode		Communication Interaction Pattern	
Dyadic	Person-Computer	Initiation-Response (IR)	✦ Initiation – Teacher asks a question ✦ Response – Students answer the question
Triadic	Person-Computer-Person	Initiation-Response (IR)	✦ Initiation – Teacher asks a question ✦ Response – Students answer the question
		Initiation-Response-Evaluation/Feedback (IRE/IRF)	✦ Initiation – Teacher asks a question ✦ Response – Students answer the question ✦ Evaluation/Feedback – Teacher evaluates the answer
		Initiation-Response-Follow-up (IRFo)	✦ Initiation – Teacher asks a question ✦ Response – Students answer the question ✦ Follow-up – Teacher asks another question

The platform is treated as a teacher. The first move is the initiation, where the teacher (the platform) asks a question to initiate student interaction in a teacher-led online platform instead of face-to-face in a classroom. The second move is the response, where students interact in response to the teacher's stimuli. The last move is the evaluation/feedback, where the students' answers are evaluated by the online platform, and it gives a reply such as right or wrong. It means that students get the correction or evaluation for their response immediately. Or the last move is the follow-up, where the teacher invites students to answer extra problems after students have made the second move. Our main contribution is the combination of evaluation, feedback and follow-up together as a single move, namely the Initiation-Response-Evaluation/Feedback/Follow-up (IREFFo) pattern but we also contribute the embedding of these two-move and three-move sequences in six problem sets.

When students are solving each problem in these six sets, they are required to analyze/synthesize all given choices and infer/obtain an answer. As illustrated in Figure 2, to enhance the interactions and responses, they are required to:

1. Insert the following types of answers inside the box using a MATH calculator mode:
    a. A mathematical expression
    b. A numeric number
2. Complete multiple choice tests
3. Match the items
4. Visualize the graph of the given function using GeoGebra as a graphical visualization aid
5. Select either TRUE or FALSE for a mathematical statement
6. Reorder/Reshuffle mathematical statements using a dragging button mode
7. Perform reciprocal marking using a checklist clicking mode

In what follows, the implementation of the reciprocal marking activities are presented. For the pilot study, all illustrated examples were taken from MATH0001 at CUHK, where 17 students participated in the in-class activities.

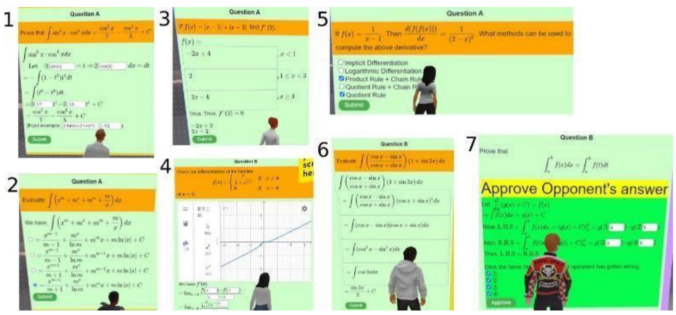

Figure 2. Seven types of interactions and responses.

4. Interplay between the metaverse and the C3 platform

Before solving any math problems, students are required to log in at Spatial.com to peer into the world of avatars, join to participate through avatars and get to know their classmates in three-dimensional fictional platforms, create a portal and discuss any math problems with them. Two solution designs are built for bridging an interplay between the metaverse and the C3 platform:

4.1 Solution Design I

In Figure 3(a), two avatars who represent two students stand in a virtual reality world. The C3-based learning platform is embedded in a virtual backboard. The users are allowed to type/click/select all the Calculus problem answers using their real world computer.

The question presented in Figure 3(b), is provided to assist students in verifying the limiting value of the given problem in a step-by-step manner and matching all information in a correct sequential order by recalling important prior knowledge of mathematical results such as quadratic equations by completing the square/minimum element of a set/trigonometric identities/a well-known limit formulae/sum of the series with two variables and giving a reason why the answer is obtained, for example, the sum of a geometric sequence formula. When a student hits the submit button, the platform gives an immediate reply! The red colour indicates an incorrect answer while the green colour indicates a correct answer.

(a) (b)

Figure 3. (a) Two players with peers who represented by avatars stand in a virtual reality world; (b) The C3-based platform provides an automatic feedback system using a computer-and-student interaction.

4.2. Solution Design II

As shown in Figure 4, where a red arrow indicates the travel of interactions from one space to another space, in a virtual reality world the users can travel different interoperable portals to join different Calculus activities. Typically, peers watch the other students to see how they interact and solve problems. When the peers have any questions, they can post their messages and voice their ideas and thoughts through typing and audio devices from their real world computers. Hence, multi social networks of avatars are created.

Figure 4. Different interoperable portals that join different Calculus activities.

4.2.1. Example 1

An example of using an initiation-response communication pattern is given in Figure 5. After students finish a two-move sequence, GeoGebra, which is embedded in the platform, allows students to plot the given function and the derivative of the given function to assist them to find their answers by, for example, inserting corresponding mathematical expressions and answers inside the box using a MATH calculator mode.

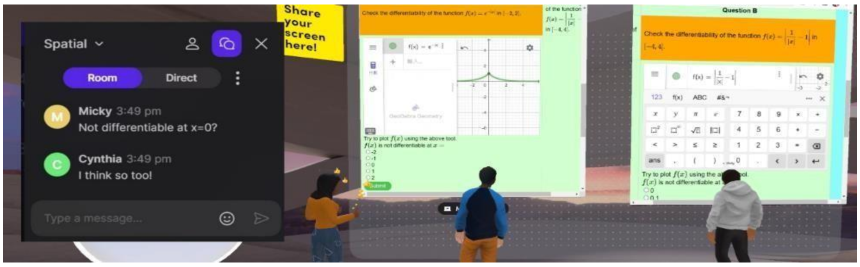

Figure 5. Inserting corresponding mathematical expressions and answers inside the box using a MATH calculator mode.

4.2.2. Example 2

As shown in Figure 6, to provide an effective follow-up response, such as peer reviewing or comparing and contrasting students' activities rather than having a simple evaluation/feedback or follow-up, we use an iterative model of the IREFFo pattern:

1. [Game Play] Students play warm up game activities.
2. [Initiation]
   a) Both students solve the same problem by filling in the blanks.
   b) Click the Submit button
3. [Response] Students mark their opponent's answers via reciprocal marking,
   a) Opponent's answer is shown in the darker green region.
4. [Evaluation/Feedback]
   a) Students select items they think their opponent got wrong. If the students think their opponent got it all correct, none of the items has to be selected.
   b) Click the approve button
   c) Each student's answer is shown in the darker green region.
   d) Both students can see what the other thinks of their answer.
   e) Both students can amend the answers that they think they did wrong.
   f) Click the final Submit button.
   g) The system will check the answers.
   Correct answers are indicated in green. Incorrect answers are indicated in red.
5. [Follow-up] Before working on the next problem, the platform will use a recommendation system to suggest other problems as follow-up questions students can use to improve their math drill skills.
   a) Both students will do the same follow-up questions and learn from them.
6. [Open-ended Question] To provide more than a short and fixed response, open-ended questions are also added in the platform. Students get a comprehensive review of the whole question and see how to get the answers and reinterpret the results.

Steps 3 and 4 are for making role changes between student and teacher, and letting peers participate in a learning process without pressure. Steps 5 and 6 provide an opportunity for users to do another learning activity whenever they want to return to the knowledge point and polish their skills.

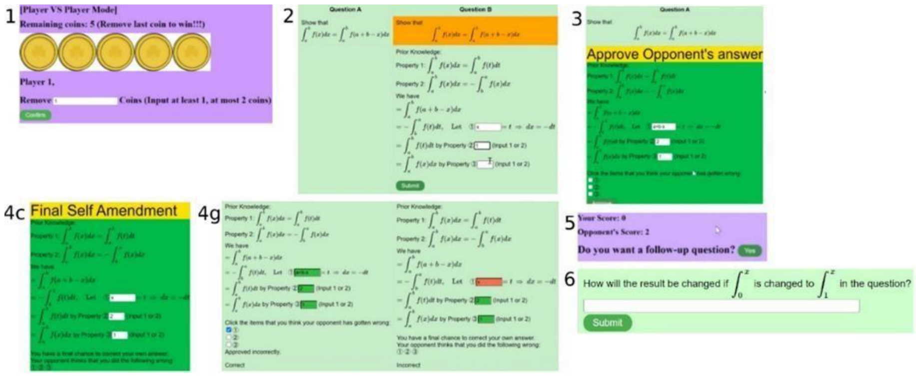

Figure 6. Illustration of an effective follow-up response from Step 1 to Step 6.

5. Conclusions

Using the metaverse together with a C3-based platform based on the frameworks of educational game strategies, and Mason's, Walsh and Satter's, and Sahin and Kulm's questioning types for teaching and learning in Calculus, helps students to diversify their social network sphere and improve their problem solving skills and their mathematical thinking processes. The C3 platform in the world of avatars and the IREFFo pattern are designed to create a more accessible relationship between the users and peers, e.g., how they are beneficial to each other. A few ongoing works are:

- collection of more student feedback data about how they work on each problem, e.g., what kinds of games students chose;
- analysis of their social networks using data mining techniques, e.g., how group members interact with each other within the group using text and voice analytics;
- embedding in the platform any metaverse tools that better fit students' needs and teachers' purposes.

These findings will be published elsewhere in future.

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Design of a Peer-To-Peer Network Framework for the Metaverse

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Abstract: This study aims to work out a peer-to-peer (P2P) network framework for real-time communication in the metaverse. The P2P network framework is designed specifically for the needs of metaverse launching on ordinary personal computers (PCs). It takes advantage of the P2P protocol to distribute data transmission, processing, and analytics on both client and server sides. The primary features of the solution can provide low-cost, high-quality, and decentralised web connections among multiple users. The innovative solution fulfils the needs for (1) scalability, (2) telecommunication, and (3) comprehensive data analysis in the metaverse. Future work is to deploy the framework in a practical context and progressively optimise the connection quality according to the activity specification of metaverse activities.

Keywords: A peer-to-peer (P2P) network framework, metaverse, telecommunication, data analytics, decentralised web connections

1. Introduction

One of the key features of the metaverse is to enable synchronous connection among multiple users synchronously (Tang et al., 2022). The client-server network framework heavily depends on the web server which may cause server overload and unstable connections. Nevertheless, the network frameworks are hard to scale up due to their high cost and the limited capabilities of servers (e.g., Queries Per Second, Transactions Per Second). The peer-to-peer (P2P) network protocol is widely applied in the online game industry to achieve a higher quality of synchronous and stable web connection (such as the Unity Multiplayers tool) (Kanazawa & Takami, 2018). However, currently, many metaverse platforms have adopted traditional client-server network frameworks, consisting of a server and many clients, such as Gather town, Minecraft, Roblox, VRChat, and World of Warcraft. There are fewer platforms in the metaverse industry making use of the P2P network framework in the metaverse. In view of this, this study aims to develop a P2P network framework as a low-cost, synchronous, and decentralised solution for the metaverse. It can support (1) scalability (2) telecommunication, and (3) comprehensive data analysis in the metaverse.

2. The P2P network framework

2.1 Design of the P2P network framework

The P2P network framework consists of server and client-sides to realise low-cost, high-quality, and decentralised web connections among multiple users (refer to Figure 1). Data transmission, processing, and analytics are designed to be distributed on both server and client sides. On the server side, a web server with Laravel platform in PHP script will be provided as the processing centre for comprehensive AI behaviour analysis. On the client side, the Unity Multiplayer tool as the P2P framework is adopted to realise the decentralised and real-time telecommunication among clients.

The Unity Multiplayer tool framework provides automatic optimisation to maintain the quality of telecommunication among users. Mainstream metaverse platforms adopt the client-server framework to let web servers act as coordinators. All data streams will go through their web servers to update the status of virtual worlds. However, If the connection between a client and the web server is unstable, it may cause the failure of display or interactions. The P2P framework enables each client to be the node in the routing map regarding their connectivity to each other. A client with good connectivity with others will be the node to collect and upload data of multiple clients and submit it to the server-side for comprehensive analysis. The system can automatically identify the best routing solution to build real-time connections among all the participants.

The server performs timely processing, and the processed files will be sent back to the host through files with timestamps, and the host will then send the processing results to other members through the P2P network. In addition, using the P2P network framework, users own their behavioural data and analysis results.

The analysis results will be stored on the user's device by default, and the user can access them locally. Also, if a client agrees to submit his or her tracking data to the server, the users as nodes can submit the raw behavioural data to the server each 10 minutes interval. If the client agrees to share their behavioural data for comprehensive analysis, a copy of the data will be sent to the server. After the data analysis is completed, the system will delete users' data from the server. Also, the client can open the dashboard to view the latest analysis results or historical records at any time.

Additionally, this framework is decentralised and stored on the client side as default. Users can decide whether the data will be shared and what data will be uploaded to the web server. Compared with the traditional client-server network framework, the P2P framework gives clients choices in advance to protect their privacy.

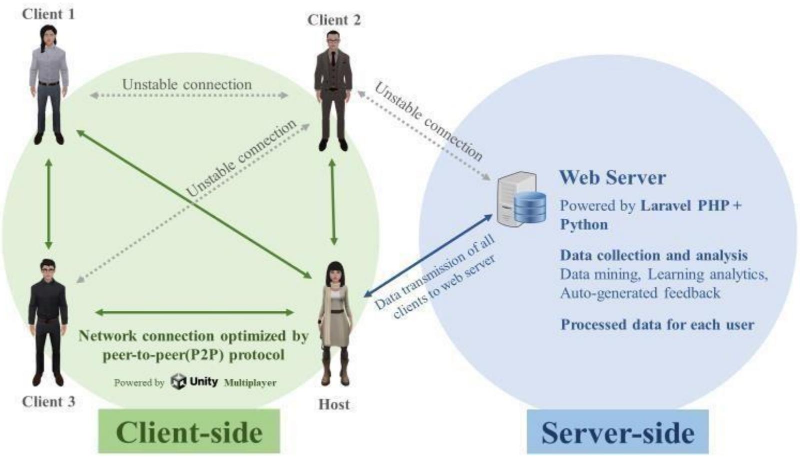

Figure 1. Design of the P2P network framework

Users can create public or private virtual spaces. (Refer to Figure 2). In the same virtual space, each user synchronises data through the P2P network (such as name, avatar image, location information, avatar pose information) (Refer to Figure 3).

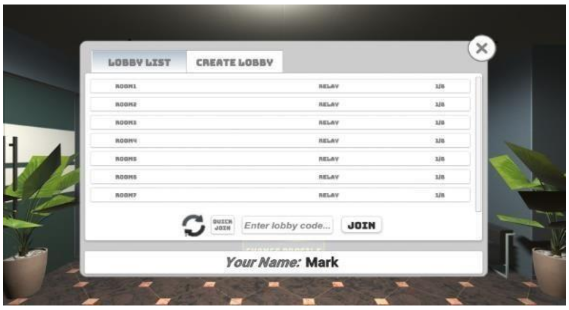

Figure 2. The interface of a multi-user lobby.

Figure 3. An example of P2P network framework-supported interactions among clients in the same virtual space.

2.2 Features of the P2P network framework

Using the P2P network framework has advantages over the traditional client-server network framework regarding (1) its low cost without a large amount of data processing on the web server; (2) supporting flexible routing rules to optimise the connection quality among multiple users automatically; and (3) decentralising the design so that users can obtain the ownership of their data and data sovereignty lies with users.

3. Advantages of the framework

The advantages of the framework can be summarised in three aspects. First, the solution can lower the threshold of the deployment of an analytics system, making real-time analysis possible. Second, the solution protects users' data privacy. The solution enables users to use the platform using the P2P network framework anonymously. Third, the solution protects users' data ownership. Data ownership refers to the possession and responsibility for data (Hummel et al., 2021). The solution allows users to decide who can be entitled to access and use the user data.

4. Future work

Currently, the P2P network service is mainly designed for video or audio chat with a uniform and consistent data flow to transmit among clients. In a metaverse context, various activities may happen randomly with different combinations. Simply and frequently conducting a global refresh will cause high consumption of system resources, which may affect the performance of the metaverse. Thus, finding an efficient and flexible data processing and packaging solution is vital to realise partial (not global) refresh in the metaverse. Future work is to deploy the framework in a practical context and progressively optimise the connection quality according to the activity specification of metaverse activities.

Acknowledgments

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Socio-technical Infrastructure Norms for Fair Use of Artificially Intelligent Education Companions: A Work in Progress

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Abstract: Use of artificially intelligent companions in education is widely appealing to learners, educational institutions, and the education technology sector. However, the use of such technology is not inherently fair, with issues such as cost, integration, security, privacy, opportunity, ethics, learning goals influencing their ability to empower and support learners. A framework to support a cross-disciplinary dialogue about the socio-technological infrastructure surrounding companions, to develop fair use implementation, is proposed.

Keywords: Guidelines, norms, educational companions, socio-technical infrastructure, ethics

1. Introduction

Drawing on a work in progress, the socio-technical infrastructure needed for fair use of educational technology (ed-tech), artificial companions are considered as an illustration of use of these developing norms. The purpose of socio-technical infrastructure is to ensure the use of technology, e.g., artificial companions, is appropriate i.e., ethical, moral and secure. Consideration of socio-technical infrastructure proactively provides support for the translation of research, in educational technologies and technology supported pedagogy, to innovation in practical educational environments.

Socio-technical infrastructure is a wide-reaching topic, the first section of this paper briefly describes key areas of infrastructure in relation to the educational technology. The second section describes an emerging framework of norms that support realizing innovation in the field of technologies within education. The final section illustrates framing a strategic dialogue in relation to artificially intelligent agents to be initiated with the ed-tech development, education and student communities.

2. What is socio-technical infrastructure and why does it matter?

Infrastructure provides a framework supporting development. Social infrastructure is a subsector of infrastructure, with its focus on utility equipment, public infrastructure, and vital objects (Grum and Grum, 2020). Social infrastructure also extends to more than the physical resources, strong social infrastructures create strong communities with resilience and the foundations for growth in both economic capital and social justice (Watson et al., 2015).

Within our context, the social infrastructure connection between internet providers, technology and educational organizations is the community under examination. With education being an essential service (UNESCO, n.d.), online education having been widespread and essential (as proven 2019 to 2022), educational technologies being at the heart of the future of education (Park, Kwon & Chung 2021), the continued massive expansion of the ed-tech sector (Hyneman, 2001), and the emergence of AI-Ed, the connections between education and technology matter more than ever in contributing to social success. The complexity of this context, with stakeholders from diverse backgrounds, makes it important to consider the future of education with clear expectations of how educational technology should be used (Dignum 2021, Institute for Ethical AI in Education 2022, Tzimas & Demetriadis 2021).

3. Framework for fair use of educational technologies – a work in progress

At this point in the larger framework project, developing an understanding of the norms that underpin fair use of educational technologies, is a work in progress. In this paper we consider the proposed norms in summary, and then as a frame for dialogue in relation to artificially intelligent companions. As this framework, and its proposed norms, are a work in progress, each must ultimately be tested. Viewing each through a lens of ethicality, morality and security will be a test of sufficiency to form the framework's foundation. Other tests are to be determined.

Norms are "an accepted standard or way of behaving or doing things that most people agree with." By employing foreshadowed norms to structure this framework we encourage general acceptance leading to a "situation or type of behavior that is expected or considered typical". (Cambridge Dictionary n.d.) i.e., a standard with some level of near future requirements is set by example rather than focusing on barriers to be overcome.

3.1 Norm One: Educational technologies must be supported by reliable access to the internet

Physical infrastructure that supports ubiquitous and reliable access to the internet is often implied as already satisfied in discussions about educational technologies; it, of course, is not (https://data.oecd.org/ict/internet-access.html and Ingram et al. 2021). Some would say this is a governmental issue (e.g., Institute for Ethical AI in Education 2022), or one of public private partnerships between internet, technology companies and educational institutions whilst acknowledging they also have risks (McShane, 2019). If this first norm cannot be satisfied, this is a barrier to educational equity and is now the limiter to advancing education in any community. It must become a priority, possibly halting other ed-tech innovation. Advocacy for and policy changes in support of wide-reaching physical infrastructure for reliable internet are an essential first norm to be satisfied and require action.

Considerations herein assumes that the first norm of the future, physical infrastructure that supports ubiquitous and reliable access to the internet, is satisfied

3.2 Norm Two: Affordable and equitable access to high speed internet services.

Low bandwidth and low speed internet also limit innovation using ed-tech. Access to high speed internet and the services and applications that require it, become our second norm. Much innovation in ed-tech presupposes connectivity, bandwidth and speed that will support constant interaction and video streaming, for example, AR/VR will become part of the normal and place additional demands on internet loads.

Reaching this norm is currently an active challenge in many areas; for example in the province of Alberta, Canada an educational technology group Cybera (2021) reports only about 37% of rural homes meet a basic service speed that would be required for education (the Canadian federal government's specified 50 Mbps download and 1 Mbps upload). These figures mean 63% of rural Albertan homes do not have internet that can support high quality online education.

3.3 Norm Three: Affordable and equitable access to educational technology

Technologies that support education vary in complexity and cost, from free open source systems to specialized systems with specialized price tags. Regardless of the product price-tag, staffing costs to support the operation of ed-tech in operation, especially if they become an integral part of an existing education system can be high. For institutions, evolution of current content management and enterprise data systems to allow integration of other technologies may pose technical and security risks, and political challenges, in addition to the cost of procurement and operations.

In the near future information delivery and discovery experiences will be augmented, incorporating AR/VR/virtual worlds. For example: medicine and dentistry are embracing teaching and assessment via computer-aided instruction, virtual patients, augmented reality, human patient simulations, and virtual reality for the assessment of students' competency. (Park, Kwon & Chung 2021). There will be many opportunities for virtuality to become a norm in education. Boards of Education will need technology partners to effectively manage both technological requirements and cost.

The issues of equity between those that readily have resources (well-funded private institutions) and those that don't, is one of time as well as fund; those ready to take on the opportunity provide their students with support and advantages sooner. Does a baseline of service access need to be provided at some point in the future? Planning for the opportunity can happen well advance of the funds being needed, thus minimizing the opportunity lag. The potential for cross communications between the tech sector, government and the education section could see some socially responsible pricing models or sponsorship advocated around all of the practical issues of access to ed-tech.

3.4 Norm Four: Unrestricted access to one's own data

This proposed norm is an ethical and moral change to the current practices of harvested data. This norm proposes ownership sits with the individual rather than the system owner or software provider. Although GDPR and cookie permissions are a good step forward in raising awareness about data harvesting and personal data use, even these initiatives follow an opt out approach to permissions regarding data harvesting and do not provide easy to access opportunity access one's own data. The educational environment, however, presents a different situation than general browsing or social posting data. In an educational environment one's own data, and analytics on one's data, could be extremely helpful in learning as input to systems providing personalized content and personalized learning environments and near continuous feedback (Gosch et al 2021).

Security and privacy needs are an essential part of norms about learner data. Schools may no longer be the end repository for learner data, the software itself may store cloud copies as part of its functionality or data is archived to the cloud. In addition to security, levels of privacy must be clear to the learner, data sharing with the system to support the learner is not the same as data archiving post learner event or data sharing with other people.

3.5 Norm Five: Controlled access to leaners' data

Learning data (opposed to student registration or demographic data) is personal rather than institutional data. In addition to existent norms around security, privacy should be an active consideration. A norm of controlled access is a way to realize privacy for the many situations in which learner data should be shared. For example, success in learning may result in the learner needing to adapt the systems or be provided with teacher support when technology feedback is insufficient for learners to get the most from their data (Tsai et al 2020). To achieve adaptation and ongoing contextual as well as technical support learners will need to permit access to their data to others.

Additionally, personal data collected for use by a learner for the sole purposes of informing personal learning has inherent issues that influence the purpose for which they can be validly used in a wider or summary context.

- Currency - As learning is an evolutionary and dynamic process, captured data may have a short currency. Data may only apply to the learner's capability within a relatively short time frame.
- Relevancy – Experimentation or taking risks can elevate learning, some learning applications can provide opportunity to try out ideas and receive immediate feedback. Learning data created this way is informative about learning strategies but not necessarily the foundational knowledge of the leaner.

Consideration of who else may access learner data and why access should be granted from a primarily ethical perspective. Other stakeholders in an individual's education (teachers, parents, school management and school boards) may have legitimate need to access learner data. The norm should however be that of making a rationale for leaner data access and use and ensuring transparency of use for example, ethical use of learning analytics (Tzimas & Demetriadis 2021). University's have well established research controls for data and this can be extended to provide ethical guidance for use of institutional data by the organization. K-12 should mirror this approach of control.

3.6 Norm Six: Quality and ethical assurance of educational applications

Matching the needs of learners and educators to educational technologies and their applications is becoming more complex as the market of ed-tech grows. Additionally, leaners and educational organizations have more nuanced needs, impacted by many of the variables raised above (e.g., cost, integration, security, privacy, opportunity, ethics, learning goals). A more supportive cross disciplinary procurement and support process is needed to ensure technologies are fit for purpose for learners, educators and their organizations. Ideally, leaners have opportunities to engage in participatory design with technology development companies. Learners should at the very least be included in participatory design for the local implementation / installation of these systems and their situational set up. In the UK, Institute for Ethical AI in Education go further in their ethical guidance which reflects learner autonomy, as a key purpose, "AI systems should be used to increase the level of control that learners have over their learning and development" (Institute for Ethical AI in Education, 2022).

In summary, in the context of this paper, dialogue in support of the first three norms should focus on understanding the situational context of the learners and the educators with respect to access to internet service: location, reliability (and maintenance of), speed of services and the technologies and applications available to them. Dialogue in support of the fourth, fifth and sixth norms should focus on placing the learner at the center of companion use.

4. Framing a dialogue: illustration with artificial companion technologies

The work presented in this paper is a work in progress. It will, with development, become a frame against which to encourage dialogue with stakeholders in K-12 and postsecondary education, acknowledging the possibility that their needs may be different as well as overlapping. At a time when the extended use of technology (especially AI based technologies) is becoming ubiquitous, supports for education about these technologies and the techniques underpinning them is lagging behind their use; guidance to ensure appropriate deployment of innovation is rapidly needed. A foundation for cross discipline communication is essential in ensure enough realistic (i.e., accurate and informed) dialogue is occurring between software engineers, AI engineers, educators right through the educational system and learners.

In this work-in-progress form, initial considerations of the dialogue about artificially intelligent companions in education is made. We can conceive conversation starting points for this cross discipline dialogue from the perspective of three stakeholder communities, shown in table 1.

Table 1. *Cross-discipline dialogue frame*

Norms 1, 2, 3 - situational context of the learners and the educators with respect to access to internet service	Norms 4, 5, 6 – placing the learner at the centre of companion use
Learners and Educators	
Questions that support learners to articulate their current access to	A range of questions can be framed to assist learners in self-advocacy around their use of artificially intelligent companions. For

internet and computing technology and access issues they experience.	example, • How will the companion help leaners meet their educational goals? • How does the companion adapt to learner needs? • Is there ongoing support of learners to get the most from their companion? Questions to build understanding about privacy of learner data, for example: • Who has access to learner data? What are the organisational policy and procedures that control access to learner data? • Where will learner data be held? Under what circumstances does data continue to be held, and are no longer held? • How will learner data used by the system?
Educators and Educational Institutions	
Questions that assess if the institution and its learners technically enabled for adopting educational companions and what can be done if they are not, for example, what are the needs for partnerships to support the technological infrastructure, access to, and design of artificial companions?	Questions around how the institution will manage the change and adoption of this new technology and concerns and impacts on its learners and other stakeholders. Reference to preparation for the change, for example, organizational policy and procedures that control access to learner data take into account socio-ethical as well as technological needs of learner?
Developers/ Innovators/ Deployers of AI companions in education	
Investigation of corporate social responsibility in this sector. For example, is the institution prepared for companion technology, or what are the needs for partnerships to support the technological infrastructure, access to, and design of artificial companions?	Questions that show how learners have or can been involved in participatory design and testing of educational companions. Questions in support of an effective procurement of educational companion technologies, for example, what is available / being done to describe the requirements, capabilities, limitations and risks of applications offered? See model cards (Mitchell et al, 2019) for an example, to promote understanding of the technologies.

Next steps in promoting cross discipline dialogue for educational technologies include defining key terminology, curating a common language if you will, to support clear dialogue; a critique and development of the ideas proposed as norms to build and evolve a realistic framework to guide dialogue; and the development of policy friendly guidance for the uptake (procurement, deployment and use) of ed-tech. These guidelines should be cross disciplinary, having relevance to the technology development community as well as the educational community, i.e., in this article's context not solely focussing on use but also on companion capabilities.

5. Conclusions

Dialogue begins questioning, can this innovation be employed? Artificially intelligent companions in education are intended to empower and support learners. Use of norms provides a frame for cross stakeholder communication to achieve these goals (empowerment and support) and protect learners data in the lifecycle of companion projects. Context of the learner environment informs the potential impact of the artificially intelligent companions in education i.e., internet access must be sufficient. Dialogue moves on to question should this innovation be employed? It includes an assessment of the value the innovation may bring and the impact its innovation may have. The benefits of artificially intelligent companions and their fitness for purpose for learners and educators should be part of the procurement process. Learner data is personal data that should be openly available to learners and have controlled use by others. As a work in progress, the proposed norms require substantial testing.

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Grounding Embodied Learning using Online Motion-Detection in The Hidden Village

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Abstract: In the learning science community, technology-based interventions afford educators and learners opportunities to augment their classrooms through engaging, interactive simulations that ground concepts in embodied experiences. The current study developed and deployed a visual novel platform called *The Hidden Village-Online* (THV-O) that used emulated 3D-motion-capture to offer students opportunities to use their bodies as a means for thinking geometrically. This paper discusses the design process for developing THV-O (e.g., narrative, UX, scaffolds) and data from a small within-subjects randomized design experiment using THV-O. Researchers administered a geometry unit using THV-O in which players performed game-directed actions prior to evaluating geometry conjectures. Students' game performance data, audio (transcripts), and video (gestures) data were processed and analyzed. Results indicated that students whose spoken responses included representational (depictive) and dynamic (enactive) gestures showed greater accuracy for intuitions, insights, and formations of transformational proofs.

Keywords: Design-Based Research, Directed Actions, Embodied Visual Novel, Action-Cognition Transduction, Embodied Cognition, Remote Learning, Inclusion & Access

1. Introduction

Grounded and embodied learning leverages bodily interactions as crucial processes in conceptual understanding and abstraction (Nathan, 2021). Fortunately, digital platforms are affording teachers and students with opportunities to embody concepts in learning environments (Georgiou & Ioannou, 2019) that provide students with grounded experiences onto which they can map mathematical ideas (Skulmowski & Rey, 2018). Nathan and colleagues (Kirankumar et al., 2021; Nathan & Swart, 2020; Nathan & Walkington, 2017; Swart et al., 2020; Walkington, Nathan, Wang, & Schenck, 2022) have developed an embodied learning environment, *The Hidden Village* (THV), that uses 3D-motion capture to allow participants to mimic movements (i.e., directed actions) of in-game avatars before responding to veracity of geometry conjectures. To date, a number of studies using THV have demonstrated when players produce game-directed actions and explanations that include mathematically relevant gestures (often re-invoking game-directed actions) they exhibit more accurate mathematical intuitions, superior insights about the relevant concepts (gist), and more mathematically valid proofs (Swart et al., 2020; Walkington et al., 2022). While this motion-based technology formerly required special hardware like infrared sensors (e.g., Microsoft Kinect) to detect body movement, advances in the focal acuity of digital cameras combined with open-source computer vision packages have enabled the research lab to develop an easily accessible web-based tool, THV-O, that tracks and records players' movements without additional hardware or client-side software. We discuss the design, development, and deployment of THV-O from proof-of-concept (PoC; Fogel et al., 2021) to an alpha version, as well as data from a pilot study addressing research questions investigating students' geometric thinking.

2. Theory

A growing body of literature in mathematics education research suggests that students working with mathematical conjectures struggle to construct viable and convincing proofs (Dreyfus, 1999; Martin et al., 2005; Nathan et al, 2021). Creating valid geometric proofs requires making universal statements about space and shapes. To adequately communicate the abstract and generalized mathematical ideas of a valid proof, students cannot rely on algorithms or procedures, such as long division, that could lead to a correct answer without a deeper understanding of the underlying mathematics concepts. While some students' struggles manifest as overgeneralizations of what can be concluded from specific examples (e.g., Healy & Hoyles, 2000; Knuth, Choppin, & Bieda, 2009), others find valid deductive proofs to be unconvincing (Chazan, 1993) or do not appreciate the essential role of deductive reasoning in establishing generalized propositions (Harel & Sowder, 1998).

People's gestures reflect their thinking; proofs constructed by expert mathematicians are often "fundamentally embodied" and often include gesture as a component of the practice of constructing the proof (Marghetis et al., 2014, p. 228). By definition, gestures are spontaneously generated hand and arm movements that are co-articulated with speech and thought (Kendon, 1972; McNeill, 1992). In effect, *gestures simulate actions* (GSA) (Hostetter & Alibali, 2008; Hostetter & Alibali, 2019), engaging perceptual-motor processes as a means for enacting thought. Reciprocally, performance of goal-directed actions—including gestures—will induce the cognitive states related to those actions. The process underlying this bi-directional relationship between thinking and acting is what Nathan (2017) calls *Action Cognition Transduction* (ACT; Fig. 1). Furthermore, *cognitively relevant* movements, which map a concept onto a set of body poses and movements and conform to gestural congruency (Johnson-Glenberg et al., 2014; Walkington et al., 2022), can be beneficial for reasoning.

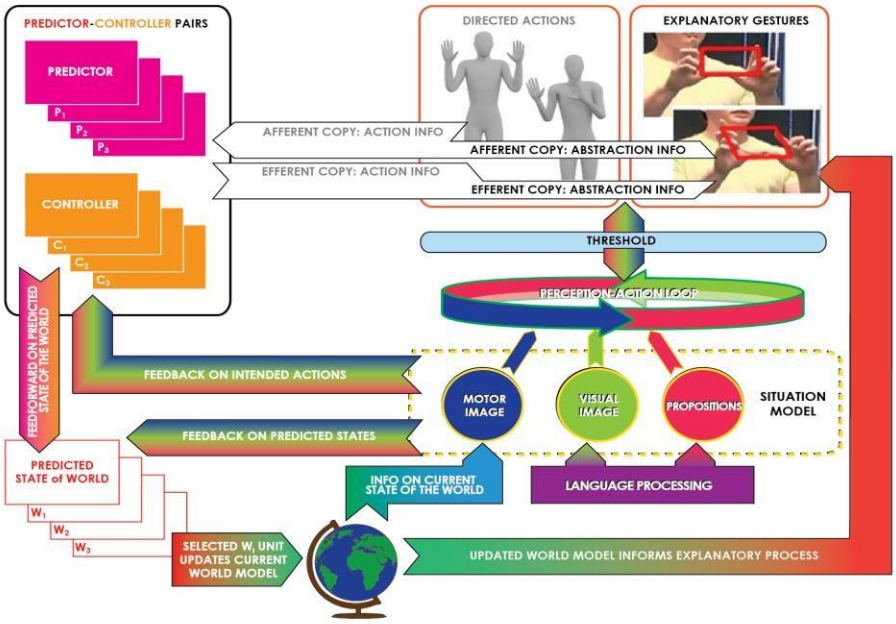


Figure 1. Action-Cognition Transduction (ACT) posits a reciprocal relationship between the environment and the learner, perception and action, and formalized through language.

Building on the theories of GSA and ACT, Nathan and Walkington (2017) developed the Grounded and Embodied Cognition framework to describe how action-based interventions can complement learners' verbal modes of reasoning as a way to influence one's mathematical reasoning. Additionally, recent work by Nathan and Swart (2020) suggests that people who produced *dynamic depictive gestures*, which are gestures that explore the generalized properties of geometric objects and their simulated transformations, demonstrated superior performance in reasoning about geometric conjectures. There is empirical evidence showing that cognitively relevant directed actions have been found to generate dynamic depictive gestures that complement mathematical reasoning (Walkington et al., 2022). As an example, students explaining the concept of parallel lines may hold up their arms or hands next to each other to demonstrate, through body movement, geometric concepts and mathematical reasoning and learning.

In educational technology development, a number of scholars have begun to identify emerging design principles for building embodied educational interventions that purposefully leverage gestures as intentional movements to ground learners' understandings (Abrahamson et al., 2020; Lindgren & Johnson-Glenberg, 2013; Malinverni & Pares, 2014). Recent research corroborates this role of the body as a promising source of educational interventions (Skulmowski & Rey, 2018), including mathematics (Abrahamson et al., 2020; Goldstone et al., 2017; Walkington et al., 2019), reading and literacy and science (Glenberg et al., 2004) and science (Lindgren et al., 2016). For design, Johnson-Glenberg et al., (2014) proposed attending to three aspects of embodiment: motoric engagement, gestural congruency, and perceived immersion.

Thus, the current study investigates the design and delivery of a geometry curriculum using THV-O (operating over the web without specialized hardware) that has participants performing cognitively relevant movements to enact key mathematical relationships. In this work, our research question asks: How do game-directed actions impact students' reasoning about geometric conjectures? We hypothesize that directed actions act as embodied scaffolds that helps structure students' conceptualizations, thus enhancing their mathematical intuitions and insights about space and shape.

3. Methods

3.1 Participants

A convenience sample of university students (N=27, $\bar{x}$ =21, n_{male}=15 (56%)) was recruited for this study. Participants were recruited through an educational psychology course and necessitated completing a high school geometry course as a prerequisite to participation. None of the students had participated in prior studies on mathematical reasoning conducted by the lab. All identifying information has been removed to protect student privacy.

3.2 Materials: An Overview of THV-O

The Hidden Village-Online (THV-O alpha version; Fig. 2) is structured as a *visual novel*, a video game sub-genre under interactive fiction. THV is designed to deliver a grounded embodied curriculum while capturing evidence of mathematical thinking by recording players' movements and speech. As a tool for research, THV-O investigates: (1) implications of design decisions for narrative, instruction, scaffolds, curriculum, feedback, reward, agency, engagement and immersion, (2) how mathematically-relevant directed actions influence students' intuitions and insights in the processes of proof production practices; (3) how pedagogical language, such as instructions, hints or narrative contexts connect players' movements to the mathematics and influences students' proof practices; (4) how learning differs when players enact or observe directed actions; (5) how collaborative embodied mathematical reasoning benefits both students and teachers.

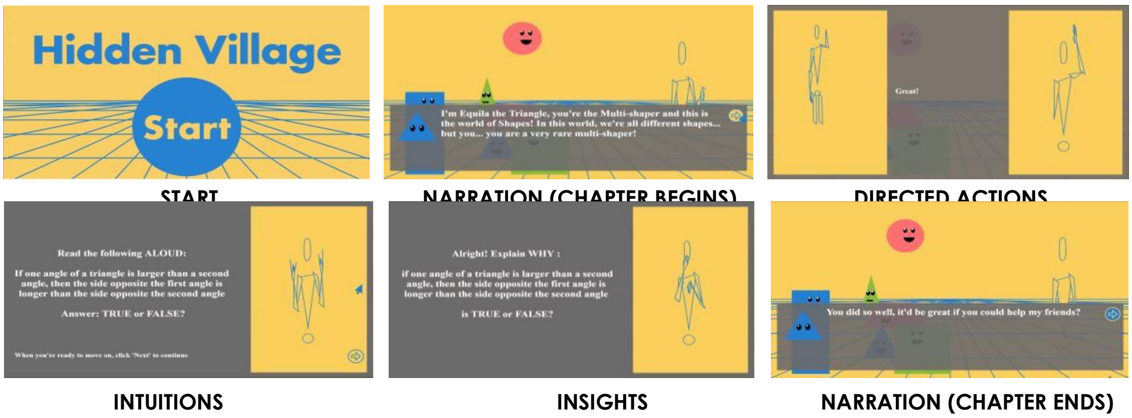


Figure 2. Top. Start Screen, the narrative begins and players match poses of the directed actions. *Bottom*. Players provide intuition, followed by insights and then the narrative progresses.

3.3 Materials: THV-O Gameplay

THV-O (Fig. 2) takes players through an eight-chapter story in a two-dimensional world populated by different shapes. Using a computer's webcam, THV-O detects participants' bodies in real-time by identifying landmarks and calculating positional data to animate the player's avatar, *The Multishaper*, on the right side of the screen (i.e., a mirror-imaged depiction in the fictional world of THV). For each chapter, participants conversed with the shape characters through captioned text; each shape introduced themselves and then asked the player (i.e., The Multishaper) to perform a movement (i.e., directed actions) after which players read a geometry conjecture and provided their intuition and insight on its veracity.

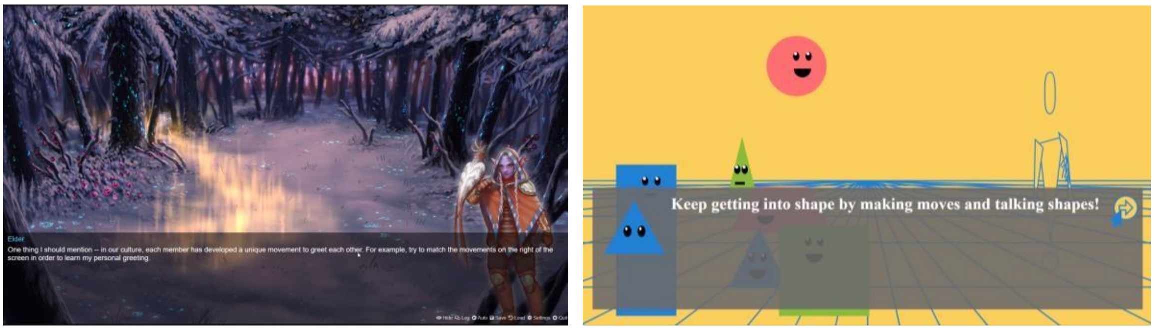
3.4 Materials: THV-O Technology

The Hidden Village-Online leverages players' movements for both navigation as well as core gameplay using consumer grade webcams and algorithmic-based software packages. Both THV-O PoC and alpha versions use Mediapipe Holistic Pose Detection Algorithm (Lugaresi et al., 2019). The Mediapipe algorithm identifies key landmarks on a player's body (e.g., wrists, elbows, shoulders, and fingers), which are used by THV-O to determine whether players have positioned their bodies in the correct poses (i.e., the directed actions). Graphics and interface for THV-O (alpha version) was implemented using ReactPixi (Brouwer, 2021) for graphics and XState.js (Khourshid, 2021) for state logic.

3.5 Materials: Improvements in THV-O

THV-O alpha version (https://www.github.com/UW-MAGIC-lab/hidden _village) created a gaming shell that allowed developers to manage and deploy custom assets, backgrounds, and characters, as well as tailor the data collection, experimental design, and game delivery modules (Latin square factorialization, conjectures, chapters, instructions, narration, navigation, pose recognition, segmentation, videos, transitions, tutorials) to the research.

3.6 Materials: THV-O Interface Redesign



THV-O PoC **THV-O alpha**

Figure 3. Interface designs for THV-O PoC and THV-O alpha.

Narrative. In THV-O PoC, the narrative situated players on a distant planet where their spaceship had crashed and in order to return home, members of *The Hidden Village* ask for assistance, in which players perform in-game movements (directed actions) before considering geometry conjectures. The revised narrative in THV-O alpha situated players in a digital world as the Multi-Shaper, there to help geometric shapes "get in shape" by performing in-game movements (directed actions) before considering geometry conjectures and returning home.

Navigation. THV-O PoC required users to click the mouse or use buttons on the keyboard to navigate through the game or to choose menu options (Figure 3, left). THV-O alpha allowed users to move an arrowed cursor using motion capture to activate hotspots displayed as buttons on-screen (Figure 3, right). These HCI improvements streamline the experience of players for an integrated and highly embodied gameplay (*ref.* Skulmowski & Rey, 2018).

Avatar, Calibration & Pose Feedback. THV-O PoC rendered players' avatars using the motion-detection landmarks, including the face, upper body, arms, hands and fingers. Calibration was delivered in real-time throughout the game as a text-based warning to position players correctly within frame. Pose feedback used a traffic light color scheme (red/yellow/green) to indicate when players directed actions ranged from incorrect to correct, respectively. Like THV-O PoC, the alpha version also used motion-detection landmarks to render players' avatars but now without facial details (the research team decided to remove the display of the facial tessellations). Moreover, to fit the new narrative, the alpha version avatars were rendered as a more stylized collection of shapes (i.e., the Multishaper). Calibration for the alpha version was delivered as a separate module at the beginning of the game and varied in two ways: (1) if players were not at the correct distance, their avatar would not render properly; (2) players performed a series of poses to train the players to understand how to use this novel interface. Pose feedback was delivered using the color red that ranged in opacity (high to low) to indicate when players directed actions were incorrect to correct, respectively.

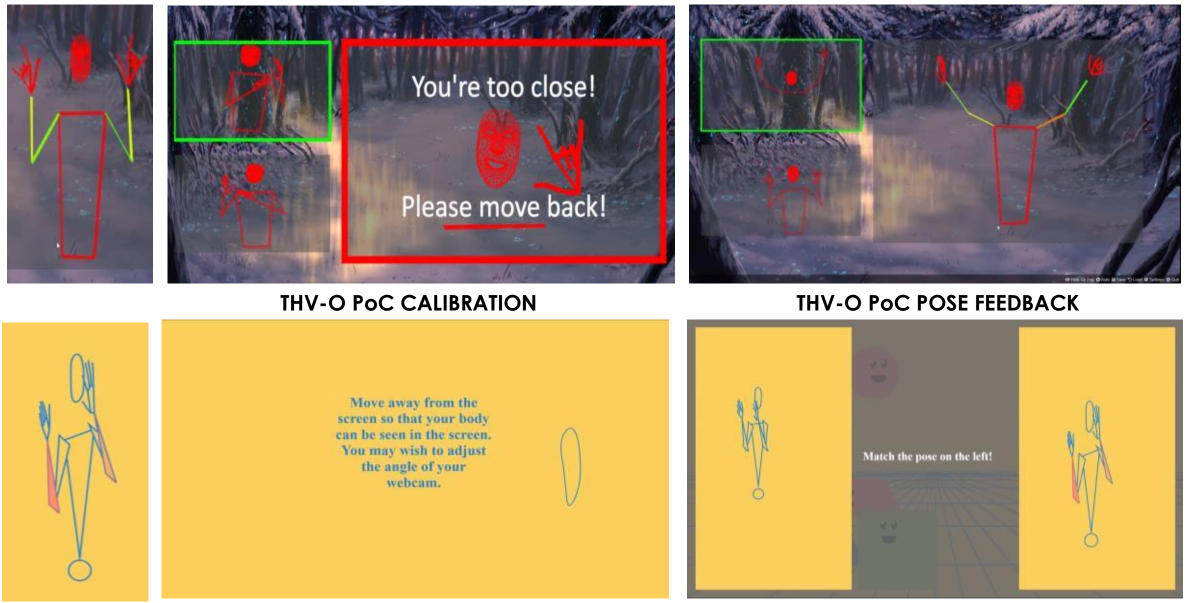


Figure 4. Avatar, pre-game calibration and pose feedback for THV-O PoC *(top)* and alpha *(bottom)*.

Open Shell. THV-O PoC delivered a game shell that was hard coded. THV-O alpha created an open shell that curriculum developers could edit by changing a human-readable reference file. Similarly, character assets could also easily updated or exchanged.

Educational Intervention Experimentation Features. As a research tool, a number of features were added to THV-O alpha, including: (1) implementing a Latin-square factorial that counterbalances the presentation order of the curriculum; (2) experimenter controls that allow customized administration of the curricular intervention; (3) interstitials that allow for variable administration of experimental protocols (i.e., within and between subjects).

3.7 Procedure

The Participants were video-recorded as they played through four chapters of the experimental platform (Figure 3). To avoid ordering effects, a Latin-square factorial design was used to order the geometric conjectures presented to participants. Finally, after completing the entire story, participants participated in a semi-structured exit interview.

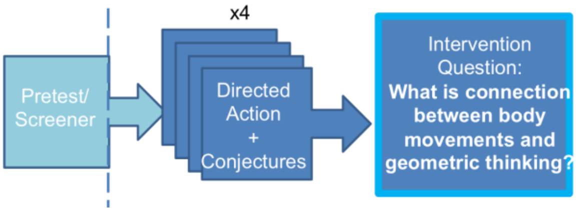


Figure 5. Participants completed a pre-test, 4 game chapters (each with a conjecture) and a post-interview

3.8 Data Analysis

Coding. The audio of the video recordings was transcribed. We then analyzed the video and transcript data qualitatively using the coding scheme described in Table 1. The coding scheme was developed using a grounded approach informed by prior analyses (Garcia & Infante, 2012; Nathan et al., 2021) on similar data. The data were analyzed gesture production on the conjecture level. Participants were video-recorded as they played through all four chapters of the experimental platform (Figure 5).

Table 1: Codebook and Inter-rater Reliability

Code	Kappa	Rho	Definition	Example
FINAL INSIGHT CORRECT	0.98	0.00	The final assessment as to whether a conjecture is true or false is **correct**; if no explicit assessment is made at the end, this will align with the assessment initially made during the intuition phase	Conjecture: Reflecting any point over the x-axis is the same as rotating the point 90 degrees clockwise about the origin. Final answer: "[false] Because if you were reflecting it over, it would be 180, 90 degrees would just be like half the rotation."
FINAL INSIGHT INCORRECT	0.88	0.00	The final assessment as to whether a conjecture is true or false is **incorrect**; if no explicit assessment is made at the end, this will align with the assessment initially made during the intuition phase	Conjecture: If you double the length and the width of a rectangle, then the area is exactly doubled Final answer: "[True] Um, if you're doubling the length and the width, then that means you're doubling all sides of the rectangle, which would in turn double the area of the rectangle."
DYNAMIC GESTURE	0.97	0.00	Gesture that depicts **both** a mathematical object or space **and** a transformation of the object	
NON-DYNAMIC GESTURE	0.95	0.00	Gesture that depicts a mathematical object or space, but **does not** transform the object; includes tracing the object in space and deictic gestures for the traces object	

Inter-rater reliability. A second coder evaluated 111 randomly selected utterances of the coded data, representing 20% of the coded utterances. A second coder, not involved in code generation or the initial coding process, coded the 111 segments. Cohen's κ was estimated for each code using the irr R package (Gamer et al., n.d.), with each code's agreement exceeding the conventional $\kappa = 0.65$ threshold for inter-rater reliability (Cohen, 1960; see Table 1). To test the how well the inter-rater reliability on a subset of the data generalizes to the rest of the coded dataset, we calculated Shaffer's ρ (Shaffer, 2017) for each code using the *rho*R R package (Eagan et al., n.d.). The Shaffer's ρ value for each code was below 0.05, indicating an acceptable Type I error rate (<0.05). These results suggest acceptable reliability for the codes used in this study.

4. Results

This randomized within-subjects pilot study employed a mixed-methodology that provided quantifiable data for the impact of a grounded embodied curriculum and further qualified that data by presenting case-study evidence that helps researchers better understand how learning is being impacted and why students' gestures reveal their conceptualizations.

4.1 Quantitative Analysis

How do game-directed actions impact students' reasoning about geometric conjectures**?** To address this research question, we analyzed the incidence of gestures through the pre-intervention tasks by evaluation performance on the conjecture (Table 1). In particular, we examined the incidence of NON-DYNAMIC GESTURES, or gestures that represent mathematical objects or spaces, and DYNAMIC GESTURES, or gestures that represent mathematical objects or spaces *and a motion-based manipulation* of the represented objects or spaces (Garcia & Infante, 2012). For example, tracing the shape of a triangle in the air would be considered a NON-DYNAMIC GESTURE as only the triangle was being represented through the gesture. However, if the gesture represented both the triangle and the area of the triangle growing or shrinking over time, the gesture would be a dynamic gesture.

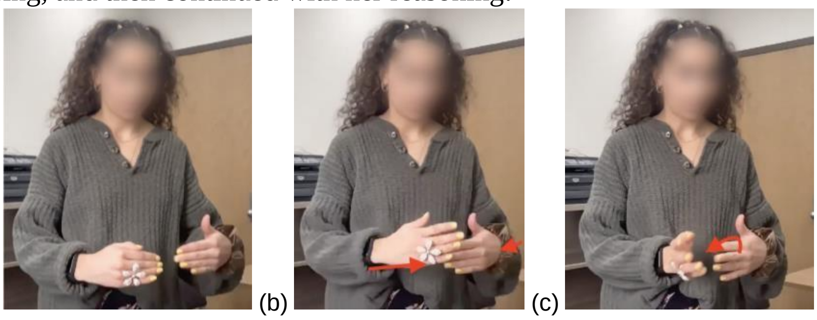
Table 2 presents the mutually exclusive gesture categories that were generated by collapsing the coded and segmented discourse data to the conjecture level. If a participant made both distinct DYNAMIC GESTURES and NON-DYNAMIC GESTURES while reasoning about the conjecture, we attributed the gesture occurrence to DYNAMIC GESTURES rather than NON-DYNAMIC GESTURES. Though participants made more NON-DYNAMIC GESTURES (43.5% of the four conjectures compared with 30.6% DYNAMIC GESTURES), participants gestured more frequently (74.1%) than not (25.9%) while using THV-O. Additionally, when participants made DYNAMIC GESTURES during the four experimental tasks, they evaluated the conjecture correctly (22.2%) more often than incorrectly (8.3%). These results support findings from Nathan and colleagues (2021), in which they found that performing dynamic depictive gestures was strongly predictive of producing mathematically valid proofs.

Table 2: Gesture Occurrence During Conjectures by Correct Evaluation

	DYNAMIC GESTURES	NON-DYNAMIC GESTURES.	No Gestures	Total
Correct	*24 (22.2%)*	*29 (26.9%)*	*21 (19.4%)*	*74 (68.5%)*
Incorrect	*9 (8.3%)*	*18 (16.7%)*	*7 (6.5%)*	*34 (31.5%)*
Total	33 (30.6%)	47 (43.5%)	28 (28.9%)	108 (100%)

4.2 Qualitative Analysis

In addition to seeing a relatively high occurrence of representational gestures when participants correctly reasoned about these geometric conjectures, qualitative analysis of the video and discourse data also suggests evidence students making dynamic depictive gestures, providing evidence for ACT while playing THV-O. In these first experimental tasks, some participants evaluated the conjecture aloud before interrupting their own explanation to perform gestures. In the example below, when the student was asked to evaluate whether a conjecture was true or false, she trailed off, spoke under her breath while gesturing, and then continued with her reasoning.



(a) (b) (c)

[1] Reflecting any point over the X-axis is the same as rotating the point 90 degrees clockwise about the origin true or false. I have to think about that...

[2] Okay. Reflecting any point over the x-axis is the same as rotating point 90 degrees...clockwise...
[3] X-axis… <*Jane moves her hands in front abdomen, see Fig. 6a*>
[4] <*Keeping her left hand in front of abdomen, Jane moves her right hand in-front of (above) her left hand, see Fig. 6b*>*…*
[5] <*Jane rotates her right hand clockwise, see Fig. 6c*>*...*
[6] Um, I think it's false cuz [because] you have to rotate 180.

Figure 6. Representative (NON-DYNAMIC) (a) and DYNAMIC GESTURES (b, c) discussing geometry conjecture.

After trailing off, the student made a NON-DYNAMIC GESTURE by moving her hands in front of her abdomen (Fig. 6a) and identified it as the x-axis. The student made a DYNAMIC GESTURE by moving her right hand over her left (Fig. 6b), and rotated her right hand clockwise (Fig. 6c), suggesting that the right hand represented the point in the conjecture. After performing this gesture, the student resumed her verbal explanation, providing a clear rationale for why she decided the conjecture was false.

5. Discussion

As a platform, the pilot data collected with THV-O demonstrates its utility as a highly embodied and integrated research tool. Traditionally, geometry concepts are presented in words, symbols, and highly regulated diagrams. In contrast, in THV-O these ideas (such as intersecting lines, reflection) are grounded in players' body movements. Future iterations of THV-O will support data collection modules that record participants' speech (audio), actions/gestures (video), and body position (motion-capture accuracy, time, attempts). While the platform currently utilizes motion-capture data to power the gameplay experience, those data are not yet collected, and thus, did not factor into the final analysis. Thus, further investigations to develop design principles and guidelines for creating effective embodied interventions (i.e., using directed actions) will help make multimodal interventions like THV-O more impactful for learning.

In this work, research question investigated how directed actions impact students reasoning about geometric conjectures, hypothesizing that directed actions serve as embodied scaffolds that help structure student's conceptualization of geometric objects and transformations (H1). The preliminary data from this randomized experiment using the alpha version of THV-O suggests that when people made dynamic gestures, they had more correct insights. Additionally, the qualitative evidence suggests that among some individuals, performing dynamic gestures that represented geometric objects and enacted transformations was an influential intermediary step in reasoning about the geometric conjectures. The data provided evidence consistent with Nathan and colleagues' (2021) finding that producing dynamic gestures is strongly predictive of producing mathematically valid proofs. These findings bolster the growing evidence for one of Action Cognition Transduction's core claims: there exists a bi-directional relationship between cognitive states and movement.

These results are not without limitations. First, the small sample size means that these results do not have enough power to generalize beyond the sample. Future work will continue to test THV-O's viability with a broader population. Additionally, participants played through THV-O in the context of a laboratory experiment. Future work will investigate its deployment as a pedagogical tool in classroom contexts. Finally, the instantiation of THV-O presented in this paper is a proof of principle representing a theory-driven design for specific geometric conjectures. Future work will expand upon the existing instantiation to investigate broader embodied design principles.

Despite these limitations, this design paper suggests that an embodied education platform such as THV-O is a viable platform for both enacting pedagogical interventions as well as continuing to investigate the qualitative nature of directed actions as learning scaffolds. To this, there is a growing corpus of evidence that suggests not only that directed actions can beneficially impact thinking and conceptualization, but that the relevance of the directed actions is crucial for effectively grounding embodied understandings of abstract concepts like geometry and improving mathematical reasoning. In some instances, individuals who may not have even be aware of the game-directed actions relevance when performing them still made deductive leaps (evidenced by their verbal and gestural explanations) while reasoning about geometric conjectures (Walkington et al., 2022). These findings, in combination with the current study, highlight that simply designing directed actions deemed relevant by a domain expert may sometimes require that participants recognize how and why those actions are conceptually salient (Rau, 2020). Consequently, further investigation is needed to understand how learners' perceptions of the relevance and salience help grounded embodied curricula. Nonetheless, we posit that making these connections explicit may make directed actions even more beneficial as pedagogical tools for teachers and students. Fortunately, the continuing development of THV-O will provide educators with the flexibility to make the connections between the movements and target concepts explicit.

Acknowledgements

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Investigating The Role of Gesture and Embodiment in Natural Sciences Learning Using Immersive Virtual Reality

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Abstract: This study reports the findings of a qualitative case study on the role of embodiment and gesture in immersive virtual reality (IVR)-enhanced Natural Sciences (NS) learning. 32 NS pre-service teachers (PSTs) participated in the study, and qualitative data were gathered through observations and follow-up focus group semi-structured interviews. From a content analysis of observations and interviews, the following assertions were arrived at: Gesture and manipulation of virtual objects enhance spatial reasoning while fostering experiential and authentic learning experiences: Both bodily (physical) and virtual manipulations in IVR-enhanced learning have a positive effect on cognitive processes, and lastly that the combination of audio, visual and embodied actions together have a higher impact of long-term memory and retention of NS concepts. Some implications and future directions are also discussed in this paper.

Keywords: Cognition, Embodiment, Gesture, Immersive Virtual Reality (IVR), Natural Sciences learning, Spatial reasoning

1. Introduction

This study reports on the role of embodiment and gesture in Learning Natural Sciences (NS) concepts within immersive virtual reality (IVR) applications. The main aim of the study was to establish the actions that contribute to learning with IVR and other possible mechanisms that could enhance the formation of mental representations when learning NS concepts. The study investigated PSTs' (also referred to as students') experiences of gesture and embodiment in IVR-enhanced NS learning. PSTs in the context of this study are students in teacher education programmes who are being prepared to become in-service teachers (practising teachers) that will take up teaching jobs upon completion of a Batchelor of Education (B.Ed) qualification. In NS learning, there are several limitations in the way concepts are learned using two-dimensional (2D) representations. These limitations include the abstract nature of concepts and the fact that representational competencies are usually limited to 2D visualisation.

One of the practical solutions to enhancing visualisation and engagement in NS learning is the enforcement of hands-on and interactive inquiry-based learning (IBL) tasks which allows students to interact with learning artefacts and ask scientifically researchable questions (Crawford, 2014). The use of inquiry-based teaching and learning strategies in science education, though beneficial for students' learning experiences, has its limitations in the lack of human and other resources for enactment, time constraints for planning and execution of classroom inquiry processes, overcrowded classrooms for interactions associated with inquiry and teacher resistance to traditional didactics (Ramnarain, 2016).

From the perspective of some cognitive scientists, "the potential to engage spatial reasoning and action-based choices while immersing students in science knowledge and phenomena is amplified by new technologies that permit more physical and expressive body input" (Lindgren et al., 2016, p. 177).

Immersive virtual reality falls in this category and holds promise for Inquiry-based and interactive learning in virtual worlds situated within VR applications. Immersive virtual reality (IVR) refers to 3D-generated artificial environments in virtual worlds that mimic real-world environments and trick the user's mind with a feeling of actually being present in the virtual world (Merchant et al., 2014). The degree of immersiveness in a virtual world ranges in scale from low immersion to highly immersive VR environments (Georgiou & Kyza, 2018; Ratcliffe & Tokarchuk, 2020). Within highly immersive VR environments, the user can interact with virtual objects and be shut out of their immediate physical environment.

Immersion is the feeling of being physically present in a virtual world (Ratcliffe & Tokarchuk, 2020). When immersed in VR, users tend to be completely shut out of the physical reality around them as the virtual environment and stimuli are engrossing (Georgiou & Kyza, 2018). Immersion can be categorised into three main types, including tactical immersion, where the user is focused on the virtual manipulation of objects using tactile operations like moving the body and hands to attain specific goals. Strategic immersion is another dimension of immersion where cognitive structures are engaged in deep thought patterns that control action within VR. The last type is narrative immersion, where the user is absorbed in a story, and the sense of hearing is fully engaged in the virtual space.

According to Björk and Holopainen (2004), immersion can be classified as sensory-motoric, cognitive and emotional, respectively, in alignment with the broad categories above. However, in addition to these three, the pair suggest a fourth category referred to as spatial immersion, which describes the feeling of conviction and realness felt within the virtual world (Björk & Holopainen, 2004). These affordances of immersion in IVR have accrued several benefits for learning and cognitive processes in Science, Technology, engineering, and mathematics (STEM) disciplines.

For NS learning, in particular, benefits associated with IVR-enhanced learning include visualisation, the enhancement of spatial reasoning, interactivity, attention focusing, acquisition of conceptual and procedural knowledge, and a boost in affective constructs like motivation and interest in STEM (Parong & Mayer, 2018). For example, in studies like Parong and Mayer (2018), participants who studied in VR were reported to have gained more conceptual knowledge and practical skills in biology. In another IVR study by Al-Amri and Musawi (2020), which looked at 3D VR physics learning for eighth graders, it was reported that besides achievement in tests, students showed gains in the affective domain of motivation.

Despite the reported benefits and learning gains reported in IVR-enhanced learning, what remains a pertinent gap is establishing the factors within IVR environments that enhance better learning and retention of learned concepts. The current research focused on the perceived role of gesture and embodiment in IVR-enhanced NS learning. The following research questions were therefore posed to propel the inquiry;

- How do pre-service teachers perceive the role of gesture in IVR-enhanced NS learning?
- What is the role of embodiment in IVR-enhanced NS learning?

2. Theoretical underpinnings

2.1 Embodiment

One of the profound affordances of virtual reality (VR)-enhanced learning is embodiment, which is rooted in the theory of embodied cognition. Embodiment is defined as the role of sensorimotoric interactions in the cognitive process or the creation of knowledge (Castro-Alonso, Paas & Ginns, 2019; Lindgren et al., 2016). The theory of embodied cognition is related to experientialism which holds that all knowledge is embodied (Niebert, Marsch, & Treagust, 2012; Goldinger et al., 2016). Social cognitivism similarly has it that social interactions play a role in cognition and affect how people learn (Adam & Galinsky, 2012). However, some proponents of the theory of embodied cognition hold that embodiment is much more than popular theory say it is. Wilson and Golonka (2013), for example, categorically stated that:

> *Embodiment is the surprisingly radical hypothesis that the brain is not the sole cognitive resource we have available to us to solve problems. Our bodies and their perceptually guided motions through the world do much of the work required to achieve our goals, replacing the need for complex internal mental representations. (Wilson & Golonka 2013, p.1)*

As controversial and radical as this proposition by Wilson and Golonka (2013) sounds to the traditional cognitivist perspective, one cannot dismiss the inherent relationship between the sensory and motoric interactions in the human brain nor the principal role these interactions have in learning and the acquisition of long-term memory. Maturana and Varela (1991), describe cognition as an "interconnected system of multiple levels of sensori-motor subnetworks" (p. 206). This theoretical position leverages the traditional capacities of cognitivism, including attention, memory, affective cognition, and metacognition (Fiske & Taylor, 2013; Goldinger et al., 2016).

2.2 Embodiment and Gesture

Strongly associated with the principles of embodiment is "gesture." Cognitive scientists have proposed models to explain how abstract concepts emerge from concrete sensorimotor experiences (Lindgren & Johnson-Glenberg, 2013). In broader terms, this notion is supported by the cognitive semantics theory of conceptual metaphor (Lakoff & Johnson, 1980), which postulates that human reasoning is grounded in schemas generated from bodily movements and interactions that are created in the imagination to give structure to abstract inferences. Evidence from diverse studies like Goldin-Meadow (2014), Johnson-Glenberg and Megowan-Romanowicz (2017) and Pande (2021) that have examined how people gesture when they solve problems or talk shows further that thinking is embodied. Gesturing through bodily movements promotes cognitive processes and thinking.

Gesture in this context refers to both the movements as a communicative form exhibited physically and the actions used to manipulate virtual objects in an IVR environment. The "gesture-enhancing-memory-trace" argument can also be framed as one of the levels of processing, which is a well-studied concept in cognitive psychology (Craik & Lockhart, 1972) in a similar position as "learning by doing". Some studies found that memory traces are improved when gesture is incorporated into the learning experience (Broaders et al., 2007; Goldin-Meadow, 2011). These findings imply that bodily movements (gesturing) within VR learning environments could be considered a "cross-modal prime" to facilitate cognitive activity like retrieval from long-term memory (Goldin-Meadow, 2014; Macedonia, 2019, Pande, 2021). In some studies, body movements have been aligned with certain learning domains, for example, learning about centripetal force and circular motion by performing circular movements instead of a linear stroke (Johnson-Glenberg et al., 2016). For the current study, the researchers assumed that motoric interactions in IVR will contribute to how PSTs learn and grasp NS concepts in 3D virtual learning environments (VLEs). The diagram in Figure 1 below shows the relationship between gesture, embodiment and learning as part of the conceptual framework of this study.

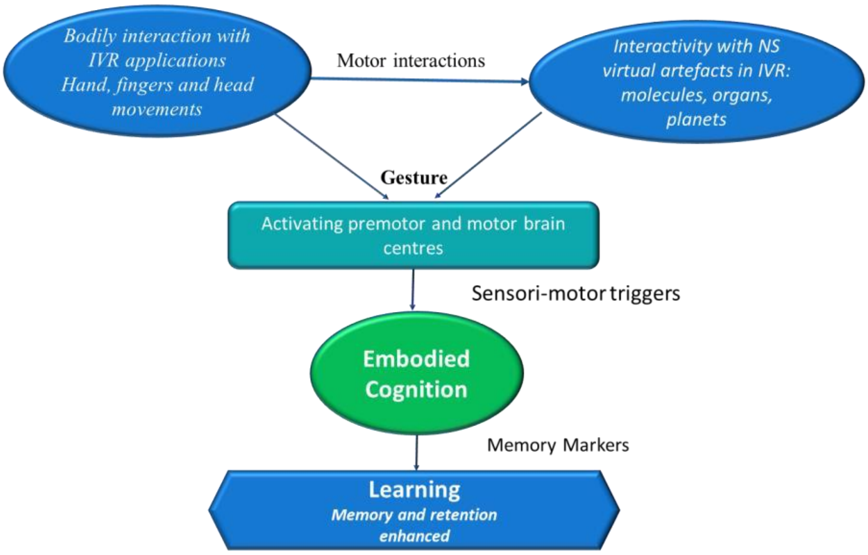

Figure1. Gesture, embodiment and learning

From Figure 1, bodily interactions in the physical (Hand, fingers and head gestures), which are motoric together with embodied actions in IVR, are all considered as gesture and will trigger sensorimotor activity. The assumption in the proposed framework is that these triggers enable embodied cognition and memory, leading to the learning and retention of NS concepts. In essence, the postulate is that embodiment has the ability to stimulate sensory responses in the pre-motor and motor brain centres, creating memory traces which aid memory and retention in the long term (Lindgren & Johnson-Glenberg, 2013; Lindgren et al., 2016). This means that the Participant PSTs in the study will learn better when their body movements and virtual gestures are employed in the learning process.

3. Methods

The research employed qualitative research methods in a case study design to gather data on PSTs' learning and interactions in IVR using observations and semi-structured focus group interviews as instruments for data gathering.

The study participants were purposively selected and included 32 Natural Sciences (NS) pre-service teachers (students) in the third year of a Bachelor of Education degree programme at a South African tertiary institution. Participants constituted twenty-one (n=21) males and eleven (n= 11) females, all of which were engaged in learning NS concepts with topics in biology, chemistry, and space science.

Once participants had been selected, they engaged in a six-week series of IVR-enhanced learning interventions using open-source biology, chemistry, and space science IVR applications. The *Oculus rift s* (a virtual reality head-mounted display) in combination with high-end *Asus* gaming laptops were used for this study. A VR application, *sharecarevr,* was selected and used for biology concepts. For chemistry, a mixed virtual and augmented reality (VAR) application, *jigspace*, was used, and for the solar system, another mixed VAR application, *ARsolar system*, was used. Three topics were targeted for learning outcomes, including the *"respiratory system"* for biology, *"combustion reactions"* for chemistry and *"composition of the solar system"* for space science. In planning and executing the learning interventions, lesson plans were first developed, and specific lesson objectives were set for each topic. An inquiry-based instructional model was considered the best teaching strategy for learning the selected NS topics in IVR. From contemporary literature, IBL modalities have proven to be most effective in IVR-enhanced learning as they allow students to participate actively in the knowledge creation process (Fegely et al., 2020; Wu et al., 2020). Because IBL instructional strategies promote interactivity and active learning, a characteristic prominent in IVR-enhanced learning, they become suitable strategies to employ in constructivist learning environments, as was the case in the current study. Participant PSTs used a guided-inquiry approach whereby they were able to engage, explore and interact with the different virtual artefacts.

The researchers developed an observation protocol for capturing different gestures and meanings based on the review of literature. The observation protocol was then used during interactive sessions to capture movements and spoken cues in the form of self-talk. Sessions were also video recorded and analysed again after each session for interpreting movements and gesture. Follow-up, semi-structured focus group interviews were conducted after the analysis of observation data as a means to get insights from participant PSTs on the meaning of their movements and interactivity in IVR after each session. The focus-group semi-structured interviews also provided room for data triangulations and validation of observed actions, which were unclear.

Semi-structured focus group interviews were audio-recorded, transcribed and analysed using thematic content analysis. Thematic content analysis is flexible and helps narrow large quantities of data into more precise and meaningful themes (Maguire & Delahunt, 2017). Thematic content analysis also provides a rich and detailed sum of all the data collected (Nowell et al., 2017), hence preferred for data analysis in the current study. Several strategies for qualitative data evaluation, including member checking, inter-coder (3 coders) reliability and an audit trail, were employed to ensure the quality of gathered data and meaningful interpretation (Nowell, 2017).

4. Results

Sample observation findings from the current study are presented in Table 1 below. The observation tool was used to record embodied actions of participant PSTs and also to provide meaning to each action recorded. PSTs were also requested to engage in self-talk during their immersive experiences with the goal of stating why they were making certain movements. Self-talk was preferred as the researchers did not have eye-tracking tools to track IVR engagements. Screes of the laptops were also being recorded by the researchers as PSTs' interacted in IVR. Table 1 below is a sample table from the observation data gathered. The table shows observed actions and how they were classified as a virtual or actual gesture. The verbal cue recorded explained why the PST was making this move, and the interpretation column was the researchers' meaning from the movements and cues.

Table 1. Observation protocol for interaction in IVR-enhanced learning

Observed bodily/virtual actions	Gesture classification	Spoken cue (self-talk)	Interpretation
Rotating head gestures	Physical gesture	Looking around to see	Creating a mental picture of a 3D image
Rotating hand gestures	Physical gesture	Looking at different angles	Establishing spatial dimensions
Annotations	Virtual gesture	Marking interesting features	Concept formation
Drag and zoom	Physical/Virtual gesture	Taking a closer look	Spatial image processing/visualisation
Pointer movements	Virtual gesture	Reflecting on a feature	Attention focusing
In-app screenshot	Virtual gesture	Keeping to re-engage after the session	Memorisation, repetition and remediation
Teleporting	Virtual gesture	Moving on to explore	Curiosity/inquiry tendencies

From Table 1, bodily actions observed as physical gestures included head rotations, hand swings (movements) and finger movements. Within the IVR environments for different VR applications, other gestures like using annotations with the aid of hand controllers, pointing, dragging, teleporting and zooming of virtual images were observed from the IVR learning interactions as part of gesture within the virtual environment.

From the self-talk data, PSTs associated different meanings with their bodily movements even as they spoke aloud. For instance, when participants were asked to provide reasons for head movements, their standard response was that they wanted to look around in the IVR environment in order to scale the environment and create mental representations of the virtual artefact. In an application like *sharecareVR*, participants used a pencil tool in the interface to make annotations on parts of the respiratory system as part of virtual gesturing. The spoken cue related to this action was that they were marking features of interest. Figure 2 below shows a PSTs' engagement in IVR on a two-by-two meters room scale.

Figure 2. PST engaged with IVR using head and hand motions

From Figure 2, the PST participant moves around in VR and engages in diverse physical and virtual gestures. Post-observation of IVR learning engagements, six semi-structured focus group interviews were conducted with all the participant PSTs to establish the role of bodily movements and gestures in their learning experiences. The following four main questions were used for semi-structured focus group interviews with participant PSTs:

- Why do you move your heads, hands, and fingers when immersed in the HDM?
- In your own words, are there any benefits for your movements and gestures when immersed in VR?
- Are there any other features of the VR applications you have engaged with that help you learn concepts?
- How can you rate the retention of learned concepts you have interacted with in IVR?

From a combination of the observation and interview data, it was clear that there were several dimensions of bodily (head, hand and finger movements) and virtual gestures, including pointing, rotation, zooming, dragging, and annotating virtual structures and images. In-app screenshots were also taken for relearning, remediation, and repetition. From the coding and analysis of the post-observation focus group interviews, three main themes were generated to answer the main research questions on the role of embodiment and gesture in IVR-enhanced NS learning.

4.1 Embodiment and gesture enhance the formation of mental representations

PSTs indicated that the ability to move one's body while immersed in VR and the actions that can be taken within IVR are essential for close examination of virtual artefacts. These movements changed the perception that PSTs had about the NS concepts being learned and enhanced their formation of mental images or representations. For example, P15 (a Pseudonym) indicated that *"I was able to interact freely with the molecules involved in the combustion of methane using jigspace in VR, I move, I zoom and even drag objects closer. This makes it easier for what I have seen to remain in my memory for long periods of time."*Another participant PST P12 in the same focus group supported P15 saying, *" I feel the same way. In my case, I could move around in a human lung by moving my head and looking at each structure carefully. I am not sure I will be able to forget the images of the different parts of the respiratory system for the longest time."* In the first focus group, P2 reported a similar experience: *"In the Solarsytem app, I felt like I was moving from one planet to another; being able to rotate the different planetary bodies as I studied their characteristics gave me a clear picture of each one of the planets. I always hated this topic, but IVR gave me a different perspective".*

These excerpts and other similar ones led to the assertion of this theme. It is evident from these findings that embodiment and gesture both in the physical and virtual spaces have a positive effect on cognitive processes, spatial reasoning and the formation of mental representations/schemas.

4.2. Embodiment and gesture enhance interactivity and experiential learning

Findings also revealed that embodied interactions within IVR spaces supported experiential learning. The PST participants revealed that freedom of movement within IVR, whereby they could use bodily gestures like head, hand and finger movements to explore molecules, organs and planets, made the learning in IVR memorable and real. For example, P21 said that *"my virtual interactions were interesting, especially in sharecareVR where I could teleport to the internal structure of an organ, move it around and really see it up close. This keeps a clear picture in my mind of the experience and the particular structure."* P 30 in the same focus group said, *"the whole VR-enhanced learning makes me interact with the things I am learning. For example, as I went into space in VR, the experience was good, but it went to another level when I realised I could drag planets, zoom in on them, rotate them and study them as if I was physically present in space*." These experiences attest to some of the aspects of experiential learning and the feeling of presence that is associated with IVR. PSTs indicated that the learning experiences were real, and they felt like they had been present in the learning experience.

In validating the role of physical gesture as well, PSTs indicated that because they were able to interact using their body movements in IVR, for instance, pushing fingers forward using thumb sticks or rotating a structure with a hand gesture, gave a natural feeling to the experiences as though they were in the real world experiencing the actions. For example, P31 said that *"when I stretched my hand out to* *touch or pinch an object in VR, I felt a feedback as though the object was actually in my hand. This made the learning experience more authentic".*

Asking about other learning aids in the IVR environment, PSTs indicated that some applications like the *jigspace* VR had textual information which aided their thinking, *sharecarevr* had labels on organ structures, while *ARsolar* system had planetarium text on the composition and characteristics of each planet in the solar system. These assertions suggest that embodiment is not a standalone system for learning concepts. There is a need for other kinds of representations that could support the learning process.

4.3. Embodiment and gesture enhance memory and retention

Recorded experiences also indicated that due to the formation of metal representations and the interactivity in IVR, PSTs could retain concepts learned for a longer period. They credit this to the ability to visualise and gesture in IVR. P11 indicated that *" I have always been good at memorising things which I forget shortly, but I realised that in IVR, I don't need to memorise the things are just fixated in my mind because I touched and played with them in VR*." This and similar opinions led to the conclusion that gesture in IVR holds promise for the way NS concepts are learned and retained in long-term memory.

5. Discussions and conclusions

Based on the findings of this study, it is clear that the role of gesture in IVR-enhanced NS learning is critical for authentic, experiential and interactive learning. In fact, the findings from this study concur with those of studies like Johnson-Glenberg et al. (2016) and Johnnson-Glenberg & Megowan-Romanowicz, (2017), which suggest that for learning to take place, the body should move rather than just focus on reading and imagining concepts. Findings from Pande and Chandrasekharan (2017) and Abrahamson et al. (2020) also allude to the fact that embodiment and gesture, which may be external, can enhance mental representations and cognitive processes. The findings of the current research also suggest that the combination of actions, interactions, visualisation and thinking are critical for learning NS concepts. These findings are also congruent with the results of studies like Alibali and Nathan (2018) and have implications for how learning interventions are designed for maximum learning gains.

In answering the research questions on the role of gesture and embodiment in IVR-enhanced NS learning, findings from the current study suggest that embodiment is undisputedly relevant for concretising scientific concepts and fostering cognition in IVR-enhanced NS learning. Gesticular movements which propel the process of embodiment were suggested by PSTs to be the actual triggers of their thought processes and spatial reasoning when learning concepts in IVR. Both physical and virtual gestures were seen to have a role in long-term memory and retention, a finding supported by Goldinger et al. (2016).

Based on these findings, it is recommended that IVR-enhanced learning in any STEM discipline be characterised by interactive gesture-provoking applications that will ensure students have an experiential learning opportunity where they can interact with the learning content. Further research on the role of embodiment in IVR-enhanced science learning could be conducted on a larger scale using a mixed methods design. For practitioners in science education, the role of embodied learning and gesture can be compared in traditional inquiry-based settings against virtual laboratory settings in IVR to establish the effects on learning.

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LA-ReflecT: A Platform for Data-informed Reflections in Micro-learning Tasks

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Abstract: Micro-learning experiences are built with short, focused activities in a technology-enhanced learning environment and also incorporates an assessment. While there are different operationalizations of the activity, it aims at learning byte-sized contents. The research initiates a design of LA-ReflecT, a platform for conducting micro-learning activities with a data-informed reflection cycle. Activities can have multiple short tasks which can have different multimedia and interaction elements. User interactions are logged in standardized xAPI format. Processed logs are presented in a dashboard to enable student's in-activity reflection. We present an initial draw implications of standardized interaction tracking that the application enables for further research on an embodied narrative of learning.

Keywords: Microlearning, LA-ReflecT, Learning Analytics, Learning Platform

1. Introduction and Motivation

Application of learning analytics aims at understanding a learning episode and supporting its continuous improvement. For the two key stakeholders, learner and teacher, involved in the learning episode, this would mean enabling - a) Knowing-in-action and Knowing-on-action and b) Reflection-in-action and Reflection-on-action (Baumgartner, 2013). Specifically in the context of Computer Science Education, research has shown the effectiveness of reflective prompts to help the learner to achieve the problem-solving skills in Introductory programming courses (Loksa et. al., 2016; Loksa & Ko, 2016). A learning design that involves such prompts can be considered as a sequence of smaller learning tasks where the learner interacts with the individual piece of content, designed by the instructor, reflects and builds on his/her existing knowledge and understanding. This is in alignment with usage of microlearning to describe shorter episodes of learning while dealing with specific task (here Problem solving task) where the learner is engaged in small and conscious steps (through reflective prompts) (Hug & Friesen, 2007). While many of the online learning platforms incorporate a learning dashboard to provide a view of the analytics, one issue remains that there is no workflow designed that lets the learners and teachers to actively review their learning and teaching activities within that dashboard (Reflection-in-action and Reflection-on-action). Hence utilization of the dashboard often remains low.

To address this issue this research aimed to design and develop a platform that enables authoring of micro-learning activities with multimedia components. Interaction of the learners and artefacts created are logged and then aggregated in a dashboard.

2. LAReflecT System Design

Learning Analytics' enhanced Reflective Task (LA-ReflecT) platform has two main components: an authoring tool where the teacher can create a microlearning activity and a viewer where the learner can attempt that activity. The platform can be linked to any learning management system (LMS) with standardized learning tool interoperability (LTI) protocol. Figure 1 presents a system architecture diagram of the platform. The user with a teacher role in the LMS has access to the authoring tool in the platform. Once they create an activity then they have to publish it to make it available in the activity viewer. The viewer has an activity attempt interface. It also logs the data of the users interactions and then can visualize the data in the dashboard.

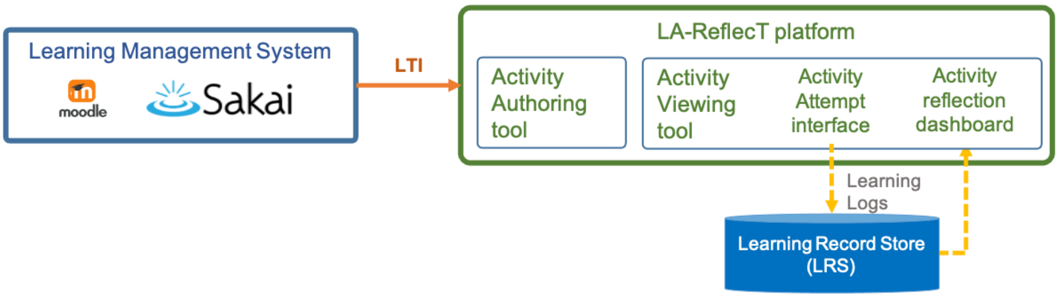

Figure 1. System architecture of LA-ReflecT platform

2.1 *Activity Authoring tool*

The authoring tool provides the teachers to create activities. Each activity can have multiple tasks. In a task the contents are organised as an element.

2.2 *Activity Viewer*

The viewer enables the user to interact with the elements of the task. It also logs the interactions, the artefact generated and the time spent on each element.

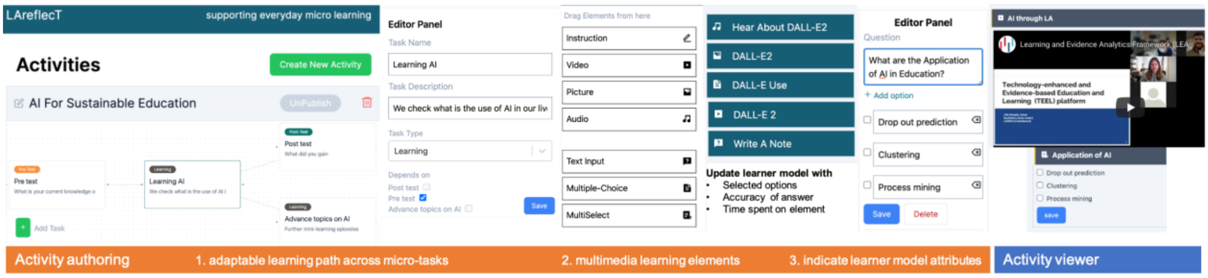

Figure 2. Workflow and interface in the LA-reflecT platform

2.3 *Learning Logs and Dashboard*

The interaction logs are stored in the LRS and provided in the learning dashboard.

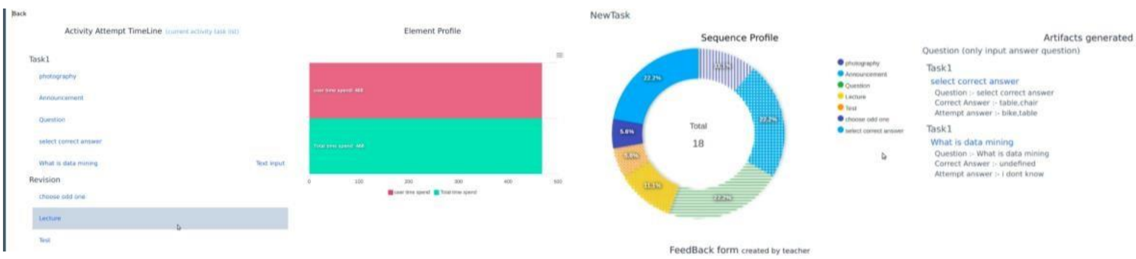

Figure 3. Dashboard visualizing interaction logs and artefacts generated

3. Pilot activity

3.1 Context

We used the LA-Reflect platform in an online Algorithms course. This course was part of an online degree program offered by an R1 university in India. In this course, learners were introduced to fundamental algorithms such as searching and sorting algorithms and algorithm techniques like divide and conquer, greedy algorithms etc. Each week, learners went through video lectures and attempted programming assignments which tested their understanding of the concepts they learnt that week.

In a programming assignment, learners were given a problem prompt, and test cases which contained an input and the corresponding required output. Learners were required to write code for the problem prompt in the learning portal. They could then run the code, and the portal showed how many test cases passed. If some test cases failed, it meant that certain parts of their solution were incorrect, or they might have missed checking some boundary conditions in their code.

We consider such programming assignments as micro-learning tasks. However, apart from feedback about the number of test cases which were passed by the system, learners do not get opportunities to reflect on how they are going about solving the problem. This is particularly important, as recent studies have shown that providing explicit reflection scaffolds to learners leads to improvement in programming skills (Loksa, 2016). Hence, we modified this programming assignment and included additional scaffolds whereby learners can reflect on how to go about solving the programming problem.

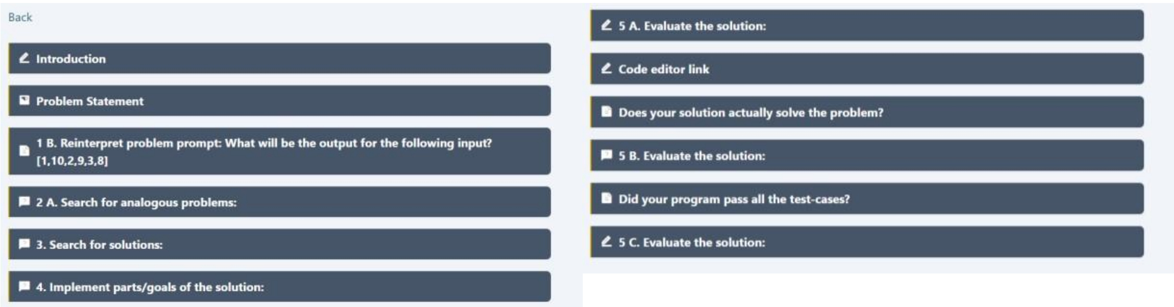

Figure 3. The Micro-learning task with additional reflection scaffolds in the LA-Reflect Platform

We used the LA-Reflect platform and added additional reflection steps for a given programming problem, as shown in Figure 3. In addition to reading the problem statement, we take learners through 5 key stages in programming problem solving, as identified by Loksa et al. (Loksa, 2016). In the micro-learning task, we make learners attempt 5 sub-tasks, namely - 1. Re-interpreting the problem prompt, 2. Searching for analogous problems, 3. Searching for solutions, 4. Implementing parts of the solution, and 5. Evaluating the solution. Learners are provided with multiple choice or open-ended response questions for each sub-task. For example, to help learners search for a solution, we provide the following prompt to learners - *"For the similar problems that you outlined before, think of how you solved those problems. What are certain characteristics of these solutions that you can use here?"*

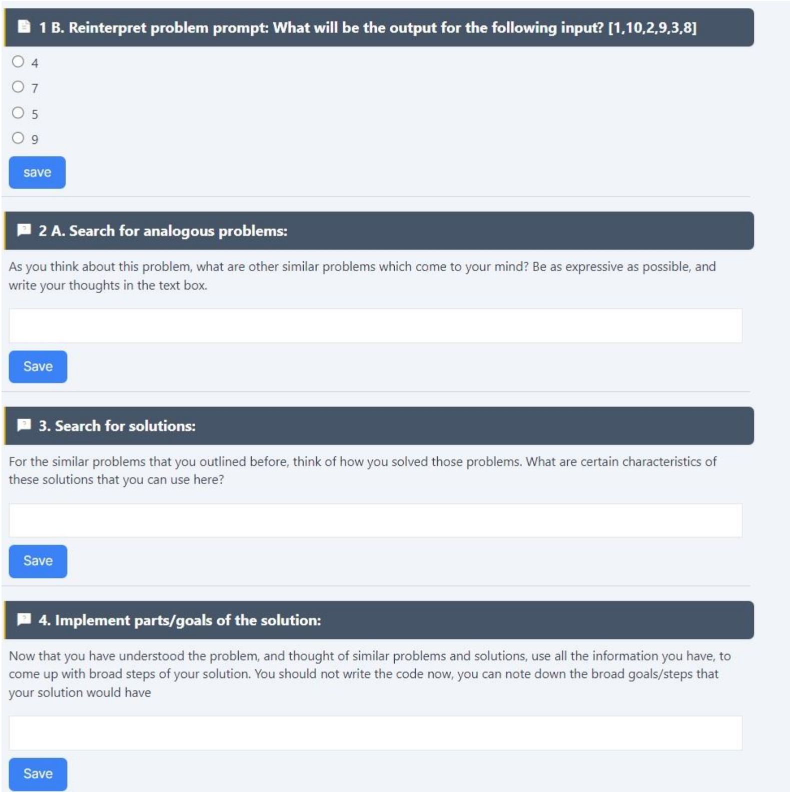

Figure 4. Problem prompts for some of the sub-tasks in the micro-learning task

Learners can attempt these sub-tasks in any order. Using these reflection scaffolds, they then write code for the given problem statement. We believe that providing learners with such reflection scaffolds in a programming problem can help them solve the problem better.

3.2 *Pilot Study*

We conducted a study with 78 participants, who were enrolled for the online Algorithms course. Participants first filled a consent form and attempted a questionnaire which measured their planning and learning motivation skills. The questionnaire was adapted from the self-directed learning instrument (SDLI) (Shen, 2014). They then proceeded to do 2 tasks in LA-Reflect. Each task had a problem statement, along with reflection scaffolds as mentioned in Section 3.1. Participants read the problem statement in LA-Reflect and could use the reflection scaffolds (see Figure 3 and 4) to write a working Python program for the given problem. They could test the correctness of their program by running the code in the programming portal, and the portal showed how many test cases passed.

3.3 *Proposed Data Analysis*

Various learner interactions such as their mouse clicks, which sub-task they are attempting, time spent in each element and answers to prompts are logged in the LA-Reflect platform. We are in the process of analyzing this data. There are two useful ways to analyse the interaction data. First, we can examine transition patterns of students across time, and see if common patterns emerge. For example, some students may follow a linear process i.e., follow all the sub-tasks sequentially. Others may go back and forth between sub-tasks. Others might spend a lot of time understanding the problem, while others might directly jump into writing the code.

Second, we can correlate transition pattern categories with the correctness of their final program (how many test cases passed). Some patterns can emerge, for example - students who spent a lot of time understanding the problem may have performed better.

The key idea is that the availability of such interaction data provides opportunities to investigate the effectiveness of reflections in the micro-learning task. Extending this idea, as part of future studies, we also intend to provide students with their own interaction data after they have attempted a microlearning task. We are interested in understanding how interpreting their own data affects their programming problem solving process and whether this has any bearings on their performance as well.

4. Discussion

This work stems from the initial attempt to design the ENaCT platform (Majumdar et. al., 2021) which just had the activity attempt interface and was logging interactions during a critical thinking task. The technical development discussed in this paper the second round in the design based research cycle where the authoring tool was presented. By allowing the authoring process (done by the teacher) to focus on development of the tasks and sub-tasks, the platform facilitates reflection-in-action for the teachers and knowing-in-action for the learners. The data based insights will further improve the reflection-on-action (for both teachers and learners) and the knowing-on-action (for the learners) thereby allowing the learners (and teachers) to go through different stages of a competency spiral (Baumgartner, 2013). The pilot implementation of the platform in the online Algorithms course, and its use by the learners has provided us with an initial understanding about the usefulness of the design from an authoring perspective. One major implication that we see with the use of microlearning framework is the need for the platform to have better integrations with traditional learning management systems so that the activity can be more seamless. The focus on one domain also limits our understanding of the types of reflection prompts that need to be supported for a larger adoption of the platform. However, we believe that the capability of allowing a broad spectrum of learning content to be integrated in the learning task would address this limitation. While the focus of this DBR iteration was primarily on the authoring, we intend to have a lesson design including the dashboard activity in our future work.

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Multiple Solution Pathways of Learners' Embodied Problem-solving Processes in Designing Authentic Computational Tasks

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Abstract: When undergraduate students engage with computational thinking (CT) activities that are authentic to them, it adds not only meaning to their problem-solving actions but also a variation to their strategies and mechanisms applied during problem-solving, termed here as learners' embodied processes. Through the perspective of designing for embodied cognition, maintaining such possibilities for variation in solution pathways could be the key to making problem-solving authentic to the learners. Using the 4E cognition narratives of two undergraduate Arts learner's pathways in solving computational tasks in an authentic setting, we speculate that such multiple solution pathways need to be evaluated in pilot studies for density of significant actions during problemsolving to prioritize the actions that show spaces which require the design of embodied scaffolds.

Keywords: Computational Thinking, IoT, Embodied design, 4E cognition

1. Introduction

Initiating novice learners into the world of problem-solving using computational thinking (CT) is challenging because the factors of identity and meaningfulness of computation remain distant from the learners' real-life context (Liesaputra, V, 2020). One of the major challenges in learning computational thinking is its associated abstractness of the concepts and procedures. Visual programming environments, such as scratch, NetLogo, Greenfoot, etc., attempted to reduce the abstractness by replacing the abstract syntax of the constructs with visual block-like elements. These visual programming environments have been proven to be significantly effective in training students' CT skills (Brennan & Resnick, 2012). A similar approach has been seen in using visual programming by Bers, Flannery, Kazakoff & Sullivan, (2014) for working with robots. Programmable robots-based learning activities reduce syntax's abstractness by employing visual programming environments similar to NetLogo and Scratch (Kim & Jeon, 2007) to program their robots. The fact that the robots are physical and tangible, and students can systematically manipulate them through coding, further bridges the gap between abstract CT constructs and reality. However, programmable robots have limitations in terms of the problem-solving contexts they offer, i.e., most programmable robots-based activities employ abstract and imaginary scenarios and lack authentic real-life problem contexts (Bers, Bers, Flannery, Kazakoff & Sullivan, 2014). Programming the robot itself when tested as a way of teaching CT, is designed through a technocentric lens (Sengupta, Dickes, & Farris, 2018) where considerable time needs to be spent in the learning curve of the technology.

This leads to some of the definitions of CT in CT education that focus on not only the skills applied in problem-solving, but also on the need to identify computational aspects and computational potential in the real world (Royal Society, 2012). Constructionist approach (Harel & Papert, (1991) and Situated learning (Lave & Wenger, 1991) based methods designed to overcome this challenge created a remarkable solution for engaging such learners with support towards connecting computational aspects in their context.

Learning while being situated in authentic real-life scenarios has been argued as a better learning practice by such literature in cognitive sciences.

Traditionally, the processes of thinking and reasoning are predominantly understood using the lens of information processing theories of cognition (Pande & Chandrasekharan, 2017; Reynders et al., 2020). These approaches assert that a problem solver first engages in the extraction of information from the content embedded in the learning or task environment and then the learner performs thinking or reasoning about 'using' this extracted information. However, the new approaches to cognition (e.g. 4E cognition; Menary, 2010; Newen et al., 2018) and situated learning (Sentance & Humphreys, 2018)) insist that cognition and knowing cannot be separated from bodily actions and context. The embedded, embodied and enactive cognition approaches regard one's thinking and reasoning processes, actions, and the environmental elements being interacted with, as *entangled* together (Pande, 2021).

In summary, we derive from our previous work that embodied narratives and analysis of actions in context intertwined with cognition would lead to the exploration of learners' problem-solving processes (Satavlekar, et al., 2021). Extending the previous work, we now look into the question of 'how' such embodied narratives can be useful from the perspective of design. We hypothesize that such exploration would be useful in identifying sites where embodied scaffolds can be designed for the novice CT learner. The situated learning and embodied cognition desirable for acquiring CT skills would also make room for reflection spots leading towards discoveries and multiple real-time problem-solving pathways, which add to the knowledge of either the technology or the CT practices for the learners.

In order to test this hypothesis, we conducted a pilot study with two undergraduate participants and provided them with IoT devices to engage in real-life computational problem-solving scenarios. Our broad research question for this study is 'What can be the implications of novice adult learners' problem-solving processes in embodied activity design rooted in real-life CT-based context?' We propose the use of IoT devices and associated utility platforms to design learning activities that can help students practice CT constructs. Utility platforms such as IFTTT, Google Home, Alexa, etc. help configure the various IoT devices to work together and allow customizations based on the user's authentic problem-solving needs. Examples of possible student tasks are given below.

> ***Example:*** *Students are given a task to configure a smart light bulb such that it automatically switches on at the start of the evening and switches off before a predefined bedtime.*

In the above example, the task of configuring the IoT devices, similar to the programming activities, will require students to apply CT skills to accomplish the needed behaviors from the IoT objects. In this paper, we propose to exploit such affordances of the IoT objects and the utility platforms to make novice CT learners practice various CT constructs by programming Real-life smart devices. These objects are slowly becoming ubiquitous in many parts of the world and society. Application of such platforms that are situated in the real-world context (Lave, J., & Wenger, E., 1991) and have an impact on everyday life activities makes them more powerful as tools to think with to nurture CT skills. This paper reports the various different pathways that were found to contain significant action-cognition sequences. While doing so, we also analyze the density of such sequences and the agent or the actors involved, to speculate the implications of designing embodied scaffolds in the future iteration.

2. Methodology

The study is an open-ended qualitative pilot investigation of novice learners' actions and cognition while solving computational thinking tasks grounded in their real-life context. The participants were chosen using convenience sampling. There were two participants, one male, and one female, (age 20 and 19 years respectively). They were second and third-year language (Sanskrit) undergraduates having no prior exposure to Computer Science in academics. These participants were chosen in order to know how adult learners who are novices to the CT domain interact with the smart programmable computational objects in their daily life and what could be challenges they face. In-person sessions were conducted over a duration of approximately 3 hours. The session included a familiarization phase and an unguided problem-solving phase as shown in figure 1. The tasks in both these phases were aligned according to the increasing order of complexity of the problem as described in the figure.

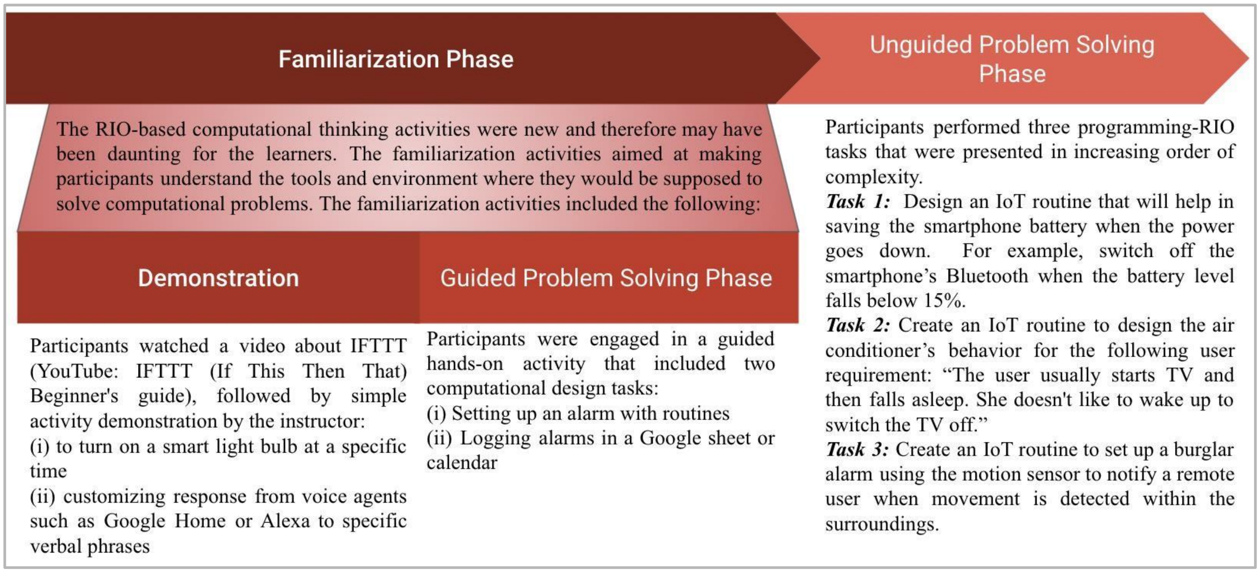

Figure 1. Phases of activities in the study (Satavlekar, et al., 2021)

Data collection and Analysis

Semi-structured interviews were administered with the objective to make the participants retrospectively reflect on their problem-solving processes. The interviews attempted to be as non–leading as possible: with questions like *"can you narrate one of the activities, how you went about solving the problem in your own words"*. However, encouraging the students to be as detailed as possible about their experience (*"Did you get bored or tired during the activities? Were there any instances which you felt interesting or could have been interesting?"*) tended to open up more information. Retrospective interviews were conducted towards the end of the study. The researcher also asked questions between the two phases, to confirm the participant's willingness to continue or abandon the next activity. In addition to the interview data, we also collected the video recording as observation data. Both the interview and video transcripts were analyzed to get a clearer picture of how the participants got familiar with the embodied environment and how they performed the given CT tasks. Using the observation and interview data from our two cases we tried to understand how the participant's engagement with the tasks in the respective sessions may have triggered CT in the participants.

Coding of the data

We performed open and focused coding of the video transcripts and identified multiple significant roles and actions corresponding to those roles associated with learners' problem-solving occurring in the unguided problem-solving phase of the session.

As seen in table 1, the roles performing as actors or agents during the problem-solving are- (i) the mentor (M), (ii) the learner (L), and (iii) the systems or application interfaces communicating through voice and visuals (S) and the combinations of two or more actors among these three. For the corresponding combination of actors, we use an abbreviated symbol as a prefix to the respective action code. The actions are inferred from the actors' problem-solving processes keeping in mind two things- (i) the list of CT skills and practices (CSTA, & ISTE., 2011) such as algorithmic thinking, logical thinking, testing, and debugging, and (ii) the response categories from the system such as showing the success of the problem being solved (RS) or expression of a constraint (C). For example, ML-DBUG specifies that the action DBUG is performed by both, the mentor and the learner, the mentor being the larger contributor. The contribution is categorized based on which actor performs as the driving anchor for that specific action. An example for clarification would be - if the learner attempts to solve a particular problem in a stepwise manner by taking the smartphone in his/her hand, we term it as L-ALGO, whereas if a mentor suggests what the learner should do next and if the learner follows or discusses upon such suggestion, we would term it as MLALGO.

Table 1. *Codes generated in data analysis showing the actors and their cognitive actions*

Encoding	Code	Meaning
Actors	M	Mentor
	L	Learner
	S	System
	LM	Learner-mentor verbal interaction
	ML	Mentor-learner verbal interaction
	LS	Learner and system verbal interaction
Actions	DSCS	Discussion
	DCMP	Problem formulation, decomposition
	XPLR	Exploring action
	ALGO	Algorithmic thinking
	LOG	Logical thinking and/ or decision making
	DBUG	Debugging actions
	ABS	Abstraction
	C	System Constraint identified or reported
	RS	Success response
	RNS	Unsuccessful response

After the encoding, we analyze the action sequences in terms of pivotal points in problem-solving - such as the problem assignment, problem decomposition, first solution, difficulty scenario faced or constraint identification, a revision (or multiple revisions) of the solution, successful final completion of the solution, and the conclusion. We identify the time spent to reach such pivot points and compare the significant actions occurring during this timespan to calculate the density of significant actions per minute. We compare the two learners' problem-solving processes in terms of the density and the learner's involvement as an actor between the particular pivot points.

3. Results

3.1 Revision and Reflection

Figure 2 shows the significant actions in context along with the learners' cognition of CT and the system in two stages: the upper part describes unguided activity 1 where the learners have to save the smartphone battery by switching off applications such as Bluetooth or reducing the smartphone brightness, etc. The first learner L1 begins with initial unguided activity and quickly designs the solution. When the mentor confirms the solution and asks the questions, *"how will you test this activity, can we check this right now"* and *"is this going to achieve what was expected in the problem statement"*, the learner faces a ***REFLECTION SPOT***, pivotal to the debugging actions ahead carried out with system application to revise the initial solution and make it more cohesive to the given problem statement. This also leads to learning about the application interfaces used for problem-solving (Satavlekar, et al., 2021) which may be useful for the learner in solving more complex problems. On the other hand. Learner 2 is motivated to ask clarification questions to come up with problem decomposition at the initial stage of problem-solving. Thus, the intrinsic motivation towards decomposing problem leads to quick revisions of own solution.

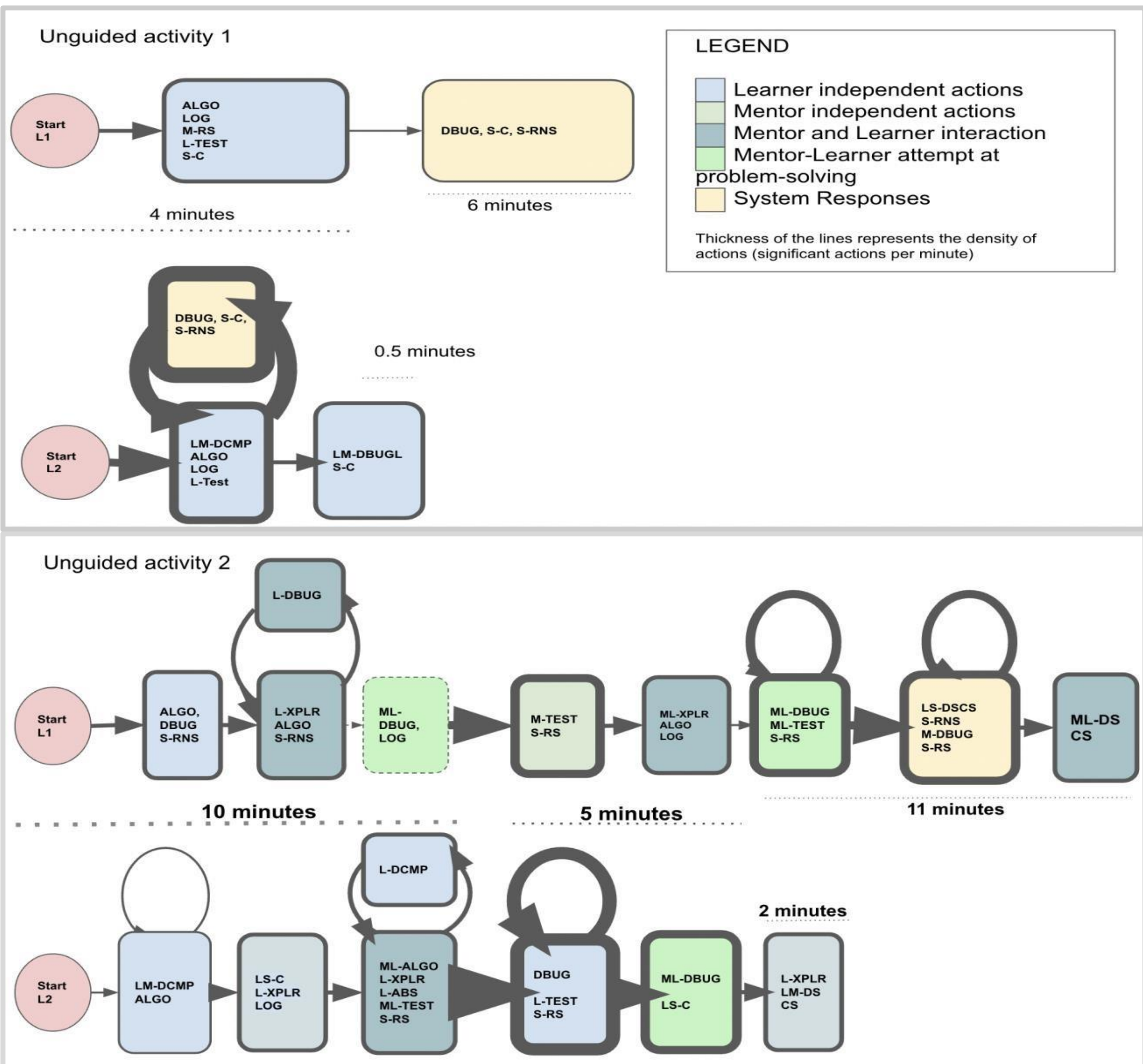

Figure 2. Learner 1 and 2's multiple pathways and density of significant actions in embodied problem solving processes of two unguided activities

3.2 Detailed Narratives: Learner 1 and 2

Analysis of a more complex activity is seen in unguided activity 2 part of figure 2, where the learner is trying to connect a motion sensor to one of the voice agents in order to program it to send an email alert when any motion is detected nearby. The learner L1 first begins with an exploration of the various smartphone applications associated with the motion sensor operation and takes approval from the mentor to try out the different applications available in the smartphone from time to time. Figuring out the proprietary application's functionality to operate the Motion sensor is relatively easy for the learner but the learner is concerned about how to integrate it with an application to set up the required routine. The second learner L2, on the other hand, begins with proactively asking clarification questions to decompose the problem and articulate the solution.

Here onwards, the learner L1 seeks a mentor's support, and together, they engage in multiple attempts to figure out which application would be suitable for the purpose, but the system shows an issue with connecting the two applications. The learner checks the manual of the motion sensor and finds Amazon Alexa can be integrated. Although the application is identified now, the learner struggles with connecting the two applications multiple times. During this entire process of thinking, following the stepwise procedure as per the procedure manual and Alexa exploration, the learner is the prominent actor operating the system application and proactively communicating with the mentor. However, as it does not yield the desirable outcome, the mentor attempts to solve the connection issue more prominently than the learner by taking control of the system application for more instances than before. Eventually, they figure out the issue and connect the two applications and the mentor shows the learner how to test and confirm that the two applications are communicating with each other and are able to detect the motion sensor. For the second learner, this link between Amazon Alexa and the Motion sensor has been established by the mentor. This allows the learner L2 to figure things out on their own without the mentor's intervention. As we can observe from the figure 2, the learner 2 spends considerably less time struggling and asking for the mentor's help in the first ten minutes. Learner 2 also stumbles upon a solution thread to the previous activity in figuring out this interface on her own, which is an important cognitive indicator.

From around 10 minutes in solving the activity, we see that the mentor is acting as the prominent support for the learner L1 in every action such as debugging, forming the revised solution by applying logical and algorithmic thinking, and helping the learner actively with the testing tasks. Whereas, for learner L2, the mentor only interferes with giving scaffolds but does not takeover the charge of the system at any point. The system application Alexa gives out a notification of motion detection sensed from the motion sensor, but the task of triggering an email remains unsolved at first for both the learners at different instances in time. The mentor assists the learners now with debugging and they finally get closer to the desired outcome. In concluding the activities, the mentor creates ***REFLECTION SPOTS*** for the learners which leads to a reflective evaluation of the solution designed by the learners as compared to the requirement of the initial problem and a discussion about the limitations of the system application. Time spent on this reflective discussion is similar (1-2 minutes) for both the learners.

Learner experience report from interview transcript excerpts

Q1. Interviewer: *"what was your experience and can you tell me say, any thing interesting you may have learnt today?"*

L1: *"Like.. exploring the apps for the first time.. Then, learning the interface or learning the features of the app.. Then third is the operating those.. With help, with guidance.. Fourth will be discovering some new operations for that. Like we did for the the motion sensor and stuff. We.. have to discover how we should link it to to Alexa.. first one. I think it would be comprehension. Like how much I would be able to comprehend with future.. This will be first test.."*

L2: "I had to find everything, right.. So it was interesting. The previous alarm and all were known like regular alarms.. These new things were completely unknown.. [Contd.] And I found one thing after another.. So it was interesting."

Q2. Interviewer: *if everything would have been already connected, do you think it would have been better to complete the tasks faster?"*

L1: *"Uhh.. for the time, when we were doing the amazon part in first half. That time I thought that ready thing would have been better.. because we have to sensor two or more times.. so that was time-consuming. But at the time we connect the motion sensor, that was new part. I mean, we have to link it through three parts.. [Contd.] So, that was just interesting part."*

Q3. Interviewer: *"Now we spent 3 hrs today. Did you feel bored? Or did you feel like 3 hrs period was appropriate?"*

L1: "*No.. I mean, first of all, this computer related stuff is interesting to me. I mean, I could perform all these tasks. So I was not bored as such. But considering time period, if we had not spent some time in the middle, we could have done more activities."*

4. Discussion

Presentation of learners' embodied processes in the context of CT-based problem-solving help us understand that it is a time-consuming process that does not follow a single straight path. The multiple pathways and struggles of the learner's cognitive processes may have been frustrating for the learner, but the answer to the interview questions Q1 and Q2 inform us that the learner was engaging in the activities with retained interest.

Takeaways from narrative

1. The prominent actors or combinations of actors vary across the whole computational thinkingbased problem-solving process. In the current analysis, this prominence is only attributed to the proactive actor in verbal communications, cognition, and actions among the three (learner, mentor, and system). No other measurement to quantify the contribution of the actors is applied here.
2. A single problem given in this context does not have a single solution, and every solution designed by the learners may not always be accurate. ***REFLECTION SPOTS*** created by the mentor for the learners play an important role in initiating the evaluation of the designed solution, attempts of identifying the limitations of the system, and also optimizing the current solution.
3. There is a need to design mentor protocol and scaffolds in such embodied problem-solving approaches involving multiple pathways and iterations such that, the learners do not become dependent upon the mentor to solve the problem. The ultimate goal of the problem-solving exercises may not be to achieve the best solution but to engage with activities that require cognitive experiences leading toward the practice of CT skills during the process. Even so, the learner's autonomy and in turn, authentic engagement may be hampered in absence of the protocol.

Speculating a takeaway from the density of significant actions

The analysis of the density of significant actions could be an important aspect while designing embodied problem-solving activities. We base this speculation on the analysis that shows how the learner L1 and the mentor had to spend significant time on activities that involved less number of computational thinking-oriented tasks in the majority part of the complex unguided activity 2 of problem-solving. We can support this speculation with the learner's answer in the first half of the Q2, that it may have been better to exclude the connection in the initial task. The learner may not desire to spend a significant amount of time on actions that are not cognitively productive for the learner. The learner may also want to reserve this time for solving more such cognitively intense tasks, as he expressed in the answer to Q3. In case of L2, having offloaded the task of connection allowed the learner to practice more productive activity of problem solving which we plan to confirm with a larger number of students in future studies.

The presented analysis of cognitive processes can also be effective in informing *WHO* is the prominent actor while dense (more significant cognitive actions in less time) are being performed. This will be useful in designing scaffolds and mentor protocol as a scaffold, such that the problem-solving activities remain authentic to the learner and the learner does not become dependent upon the mentor, as stated earlier. We end this discussion with the issue that in this study we have only analyzed two learners' actions through embodied narrative and we do not intend to make any claims about the design or learner experience because of the small sample. Our analysis of the second learner shows that the pathways followed are even more different in terms of actions of problem-solving, cognitive processes, the time taken to uncover each point of success, limitations, and revision. However, both the learners completed the activities with enthusiasm and expressed interest in solving more such complex computational problems in their semistructured interviews. Presenting an experience report and starting the discussion about a novel angle of analysis with importance to the density of significant actions in these multiple pathways is our sole intention. We need to iterate this analysis over our next study participants to provide strong support to the speculated embodied design implication. An analysis similar to or inspired by the one presented in this paper, exploring the multiple pathways of learners' embodied problem-solving processes in a real-life CTbased context may be a rich source of information to tap into to design more embodied activities for the future.

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Exploring the Impact of Game-based Learning on Students' Creativity from the Perspective of Interest, Relationship and Opportunity

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Abstract: Game-based learning has become an important trend in artificial intelligence assisted teaching. Based on the framework of connected learning, this study analyzes the influence mechanism of game-based learning on students' creativity from three aspects of interest, relationship and opportunity, and concludes that game-based learning, as a form of constructivist learning, can better promote connected learning. In this study, 56 students in Z province of China were investigated by questionnaire, and SPSS 23.0 and smart pls were used for statistical analysis. The results show that interest (academic interest and technical interest), relationship (collaborative tasks and common goals) and opportunity (learning time and learning cost) have a significant positive impact on the level of creativity improvement in game-based learning. In addition, self-efficacy can also play a significant positive role in the creativity of game-based learning. The research can help students better participate in game-based learning and master knowledge, and link students' in class learning and extracurricular learning, stimulate students' learning motivation, enrich classroom forms, and create a good learning environment.

Keywords: Game-based Learning; Connected Learning; Creative Ability; Information Technology

1. Introduction

In recent years, games have been widely recognized as essential to the development of teenagers. It provides a way for children to explore the world and acquire knowledge about how society works (Gros, 2007), which can help teenagers understand and explore the world, and stimulate their natural curiosity (Undiyaundeye, 2013). But for many teenagers, the opportunity to play has become increasingly scarce (Essame, 2020). Game-based learning refers to learning in a gamified way relying on modern educational technology. Game-based learning integrates numerous applications such as social media and digital software (Karaganis, 2007). Orlikowski & Scott (2008) pointed out that game-based learning integrated by digital platforms and virtual communities is a value embodiment of creative digital learning. Dougherty (2013) believes that game-based learning can promote the technology and ability of students to use information technology and support the development of students' maker thinking. Therefore, game-based learning is indispensable in the comprehensive training requirements of today's teenagers.

However, the current research is limited to the design and development of game-based learning, and it has not effectively combined with instructional design theory to analyze learning. Therefore, according to the interconnected learning framework of Ito et al. (2013), learners' in-class learning should be better interconnected with their extracurricular learning. Rapeepisarn et al. (2006) pointed out that peer supported game-based learning relies on technology and can effectively become a teaching strategy combining learning activities in and out of class. Laakso et al. (2021) believes that when students can use their extracurricular interests and skills in in-class learning, learning engagement and creativity will be enhanced.

Therefore, the research aims to provide structured teaching support for improving students' creative ability and research ability of information technology (Hakkarainen et al. 2000), and effectively link students' learning in and out of class. This study investigated the game-based learning in which college students participated and constructed a structural equation model based on the connected learning framework to combine the improvement of creativity from game-based learning with connected learning. To sum up, this study raises two research questions:
Q1: Do interests, relationships and opportunities influence students' creativity in game-based learning? Q2: In what ways should students, parents and teachers combine connected learning with game-based learning?

2. Literature Review

2.1 Connected Learning

Connected learning can effectively combine the three parts of personal interest, support relationship and learning opportunities, which is fundamentally based on the constructivism theory (Fosnot, 2013). Ito et al. (2013) believes that connected learning should be based on and motivated by students' interest in funding, while Maul et al. (2016) pointed out that connected learning should be supported by peers and other learners and oriented to support students' academic research. At the same time, Ito et al. (2013) pointed out that the connected learning framework involves three design principles. First, collaborative activities should focus on advancing a common purpose. Second, focus on creating tangible products. Third, open networking so that everyone has the opportunity to participate in and access distributed cognitive resources. Therefore, connected learning emphasizes the importance of student participation in learning and creating collaboration. Hughes-roberts et al. (2020) pointed out that game-based learning based on connected learning can provide inspiration and encouraging learning experience for different learners. Based on the above discussion, Hypothesis 10, Hypothesis 11 and hypothesis 12 are proposed in this study:

H10: Personal interest has a positive impact on game-based learning creativity.
H11: Peer relationship has a positive impact on game-based learning creativity.
H12: Learning opportunities have a positive impact on game-based learning creativity.

2.2 Interest

In game-based learning, students' personal interest includes academic interest, artistic interest and technical interest. Dotterer et al. (2009) pointed out that adolescents' academic interest generally declined over time, and the decline in adolescents' academic interest was related to the decline in school performance. Silvia (2005) pointed out that artistic interest can affect the cognitive evaluation of adolescents, and the relationship between people is not regulated by individual differences related to artistic interest. Buccheri et al. (2011) pointed out that while interest in specific technologies can support career choices in some technical fields, gender plays a limiting role. Based on the above discussion, H1, H2 and H3 are proposed in this study:

H1: Academic interest has a positive impact on personal interest.
H2: Artistic interest has a positive impact on personal interest.
H3: Technical interest has a positive impact on personal interest.

2.3 Relationship

Peer relationship in game-based learning includes three parts: collaborative task, peer support and common goal. De Vreede & Briggs (2005) expanded intra-group and inter-group communication through Computer-supported Cooperative Work (CSCW) to achieve an appropriate match between collaboration and task requirements. Mead et al. (2001) stated that peer collaboration enables individuals to achieve the capacity for personal, relational, and social change in learning communities. Brown et al. (1986) pointed out that learners with common goals are willing to exchange professional knowledge and learn from each other, and personal contributions as well as shared beliefs and values will be regarded as supporting factors. Based on the above discussion, H4, H5 and H6 are proposed in this study:

> H4: Collaborative tasks have a positive impact on peer relationships.
> H5: Peer support has a positive impact on peer relationships.
> H6: Common goals have a positive impact on peer relationship.

2.4 Opportunity

Learning opportunities in game-based learning include three parts: weekly game-based learning time, game-based learning frequency, and game-based learning cost. Learning time and learning times per week can effectively reflect the learning frequency of learners. When learners are exposed to game-based learning more frequently, learning opportunities will increase. Lam et al. (2011) pointed out that more frequent learning opportunities can improve task performance in learning. Becker (2000) pointed out that families with high socioeconomic levels have more opportunities to use computers and the Internet at home. Evans & Kantrowitz (2002) pointed out that families with low socioeconomic levels are less likely to use these facilities for game-based learning. Based on the above discussion, H7, H8 and H9 are proposed in this study:

> H7: Perceived game-based learning time has a positive impact on learning opportunities.
> H8: Perceived gamification learning frequency has a positive impact on learning opportunities. H9: Perceived game-based learning costs have a positive impact on learning opportunities.

2.5 Self-efficacy

Tierney & Farmer (2011) pointed out that the increase of learners' self-efficacy can improve learners' creative performance. Meanwhile, Tierney & Farmer (2002) pointed out that self-efficacy can predict creative performance in addition to learning efficacy. Jaussi et al. (2007) believes that personal identity, self-efficacy and experience play a cross role in learning creativity. Haase et al. (2018) pointed out that the relationship between measures of self-efficacy and creativity depends on the type of measure used, especially between self-report scales and more objective testing procedures. Therefore, based on the above discussion, H13 is proposed in this study:

> H13: Self-efficacy has a positive impact on the improvement of game-based learning creativity. To sum up, the research architecture proposed in this study is shown in Figure 1.

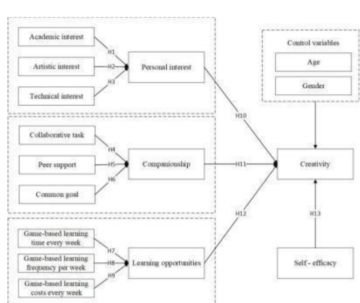

Figure 1. Study Architecture Diagram

3. Methods

3.1 Questionnaire Design

The question design of this study was mainly modified with reference to existing questionnaires in Laakso et al. (2021), Shute & Wang (2016) and Schmidt et al. (2009). The questionnaire included 5 personal interests (e.g. I can use Word, Excal, PPT and other learning software), 5 peer relationships (e.g. Everyone is trying to achieve the same goal in game-based learning) and 5 learning opportunities (e.g. My financial condition can support game-based learning). A 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree) was used to indicate how much the respondent agreed with the item.Before issuing the formal questionnaire, this study conducted a pilot test on the content of the questionnaire, and 16 people participated in the pilot test. The reliability analysis of the indicators in the questionnaire showed that the Cronbach α value of all indicators was greater than 0.7, so the formal questionnaire was issued.

3.2 Data Collection

This research within the scope of Z province colleges and universities in 2022 through the questionnaire system, for open gaming learning questionnaire investigation of the colleges and universities. In terms of questionnaire recovery, a total of 68 questionnaires were collected through the Questionnaire system (WJX), and 12 invalid answers from the unified login account that took less than 30 seconds to fill were deleted, resulting in a total of 56 valid questionnaires and finally 56 valid questionnaires, which were used for formal data analysis. The basic information of the research object is shown in Table 1 below.

Table 1. Basic Information of the Research Object

Project	Group	Quantity	Proportion
Gender	Male	31	55.36%
	Female	25	44.64%
Learning stage	Primary school	8	14.29%
	Junior high school	13	23.21%
	High school	11	19.64%
	University	24	42.86%
Game-based learning frequency per week	high	13	23.21%
	middle	30	53.57%
	low	12	21.43%
Game-based learning time every week	high	9	16.07%
	middle	29	51.79%
	low	18	32.14%

Learning frequency: more than 7 times per week is the high learning frequency, 3-7 times is the middle learning frequency, less than 3 times is the low learning frequency; Learning time: more than 21 hours per week is the high learning time, 7-21 hours is the middle learning time, less than 7 hours is the low learning time.

4. Results

4.1 Reliability Test

Cronbach's Alpha and combined reliability were used to assess the internal consistency of the variables. As shown in Table 2, Cronbach's Alpha of all variables was between 0.73 and 0.94, exceeding the threshold of 0.70 (Nunnally, 1978). The combined reliability of all variables was between 0.76 and 1.00, which exceeded the acceptable value of 0.70 (Fornell & Larcker, 1981). Therefore, the study variables have certain reliability.

Table 2. *Reliability and Validity Analysis Results - Compound Reliability, Cronbach Coefficient and Mean Draw Variation*

	Cronbach's Alpha	rho_A	CR	AVE
Academic interest	0.93	0.89	0.91	0.90
Artistic interest	0.86	0.88	0.91	0.97
Technical interest	0.85	0.75	0.76	0.74
Collaborative task	0.94	0.75	0.75	0.97
Peer support	0.79	0.80	0.80	1.00
Common goal	0.73	0.72	1.00	1,00
Learning time	0.84	0.89	0.74	0.74
Learning frequency	0.89	0.81	0.95	0.73
Learning cost	0.96	0.89	0.77	0.76
Personal interest	0.84	0.75	0.94	0.97
Companionship	0.86	0.77	0.95	0.92
Learning opportunities	0.82	0.92	0.85	0.80
Self - efficacy	0.94	0.79	1.00	0.97
Creativity	0.88	0.80	0.84	0.73

4.2 Validity Test

The purpose of discriminant validity is to test the discrimination degree of measured variables between different constructs. Fornell-larcker method and Heterotrait Monotrait method were used to test the validity of the study (Fornell & Larcker, 1981). The results are shown in Table 3 and Table 4. As can be seen from Table 3, the square root value of the average extracted variance value is greater than the correlation coefficient between constructs, indicating that the results of each construct have discriminant validity. As can be seen from Table 4, the highest HTMT value is 0.94, which is within the acceptable range, and the student sample meets all the standards. Therefore, the results of each construct have discriminant validity.

Table 3. *Fornell-larcker Method*

	a	b	c	d	e	f	g	h	i	j	k	l	m	n
a	1.00													
b	0.58	1.00												
c	0.65	0.58	1.00											
d	0.72	0.73	0.74	1.00										
e	0.36	0.70	0.45	0.55	1.00									
f	0.50	0.57	0.69	0.75	0.46	1.00								
g	0.64	0.60	0.84	0.70	0.38	0.61	1.00							
h	0.32	0.41	0.39	0.36	0.50	0.24	0.44	1.00						
i	0.51	0.34	0.51	0.47	0.21	0.46	0.60	0.20	1.00					
j	0.28	0.17	0.39	0.25	-0.02	0.31	0.34	0.11	0.32	1.00				
k	0.64	0.44	0.55	0.48	0.20	0.54	0.54	0.03	0.46	0.46	1.00			
l	0.60	0.65	0.87	0.77	0.44	0.68	0.75	0.30	0.59	0.33	0.55	1.00		
m	0.12	0.07	0.23	0.13	-0.04	0.13	0.28	-0.14	0.39	0.44	0.28	0.31	1.00	
n	0.53	0.39	0.46	0.47	0.16	0.55	0.55	0.00	0.50	0.39	0.91	0.48	0.316	1.00

A. Personal interest; B. Common goal; C. Creativity; D. Collaborative task; E. Companionship; F. Peer support; G. Learning opportunities; H. Academic interest; I. Learning cost; J. Technical interest; K. Learning time; L. Self-efficacy; M. Artistic interest; N. Learning frequency.

Table 4. *Heterotrait-monotrait Method*

	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**m**	**n**
a														
b	0.58													
c	0.65	0.58												
d	0.72	0.73	0.74											
e	0.36	0.70	0.45	0.55										
f	0.50	0.57	0.69	0.75	0.46									
g	0.64	0.60	0.84	0.70	0.38	0.61								
h	0.32	0.41	0.39	0.36	0.50	0.24	0.44							
i	0.51	0.34	0.51	0.47	0.21	0.46	0.60	0.20						
j	0.28	0.17	0.39	0.25	0.02	0.31	0.34	0.11	0.32					
k	0.64	0.44	0.55	0.48	0.20	0.54	0.54	0.03	0.46	0.46				
l	0.60	0.65	0.87	0.77	0.44	0.68	0.75	0.30	0.59	0.33	0.55			
m	0.12	0.07	0.23	0.13	0.04	0.13	0.28	0.14	0.39	0.44	0.28	0.31		
n	0.53	0.39	0.46	0.47	0.16	0.55	0.55	0.00	0.50	0.39	0.91	0.48	0.32	

A. Personal interest; B. Common goal; C. Creativity; D. Collaborative task; E. Companionship; F. Peer support; G. Learning opportunities; H. Academic interest; I. Learning cost; J. Technical interest; K. Learning time; L. Self-efficacy; M. Artistic interest; N. Learning frequency.

4.3 Structural Model

In this study, Bootstrapping was used to evaluate the PLS results, and 5,000 re-sampling was used as the sampling method (Freedman, 1981). The analysis results of the structural model are shown in FIG. 2. In terms of the explanatory power among individual constructs, the R2 of creativity is 83%. Based on such results, it can be predicted that this study is a model with good explanatory power.

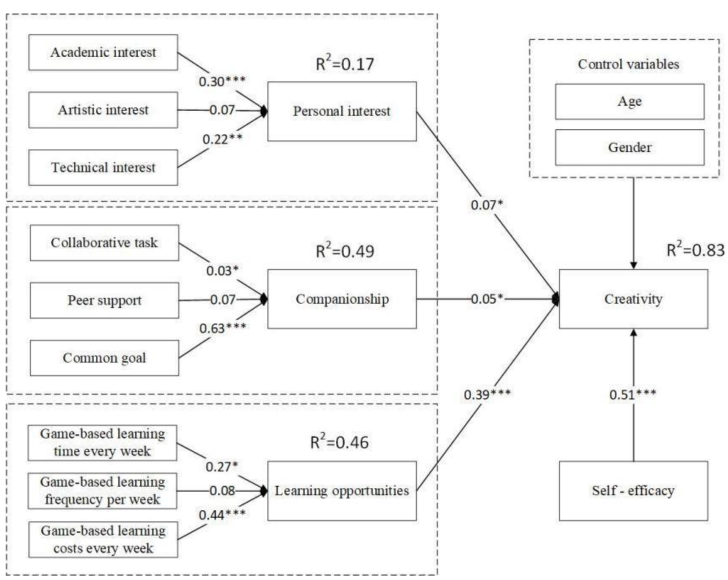

Figure 2. Research Results

According to the structural model analysis results in Table 5, R^2 value is used to measure the prediction ability in the sample. F^2 determines the change of R^2 value when the specified exogenous structure is omitted in the model, and the range is 0.02, 0.15 and 0.35, representing the small, medium or large effect of exogenous structure respectively (Hair et al.,2016). Therefore, F^2 in this study indicates that the structural model has moderate predictive power.

Table 5. *Summary of Structural Model Analysis*

Hypothesis	**Project**	**Path Coefficient**	**T**	**P**	**F^2**	**Result**
H1	Academic interest -> Personal interest	0.30	3.03	0.00	0.10	Support
H2	Artistic interest -> Personal interest	0.07	0.47	0.64	0.00	Nonsupport
H3	Technical interest -> Personal interest	0.22	1.18	0.00	0.04	Support
H4	Collaborative task -> Companionship	0.03	0.15	0.04	0.00	Support
H5	Peer support -> Companionship	0.07	0.51	0.61	0.01	Nonsupport
H6	Common goal -> Companionship	0.63	3.34	0.00	0.37	Support
H7	Learning time -> Learning opportunities	0.27	0.80	0.06	0.02	Support
H8	Learning frequency -> Learning opportunities	0.44	0.23	0.82	0.00	Nonsupport
H9	Learning cost -> Learning opportunities	0.08	3.30	0.00	0.27	Support
H10	Personal interest -> Creativity	0.07	0.75	0.03	0.02	Support
H11	Companionship -> Creativity	0.05	0.63	0.02	0.01	Support
H12	Learning opportunities -> Creativity	0.39	2.66	0.00	0.35	Support
H13	Self - efficacy -> Creativity	0.51	4.07	0.00	0.60	Support

5. Discussion

5.1 Personal Interest and Creativity

It is found that academic interest and technical interest have significant positive influence on personal interest, while artistic interest has positive but insignificant influence on personal interest. Lee (2019) pointed out that art is not easy to be perceived in game-based learning, and knowledge and skills are the main training objectives of teacher educators in game-based learning, and teachers tend to ignore the role of art in the classroom (Shah & Foster, 2015). Game-based learning provides a productive environment for themed learning units, learning computational skills, and improving creativity (Riikonen et al., 2020). In addition, personal interest plays a significant positive role in students' creativity, which is consistent with previous studies. Ford (1996) pointed out that creative and habitual behaviors represent the behavioral orientation of learners' personal interests and competing behavioral choices. Boldt & Paul (2010) pointed out that the creation process of game-based learning can attract students, help students to have better insight and introspection, and promote students' external sharing.

5.2 Companionship and Creativity

In this study, collaborative tasks, peer support and common goals are conducive to the formation of good peer relationships, but peer support has no significant effect on peer relationships. The reason may be that there is still less group cooperation in the process of game-based learning (Pek & Koh, 2021), and more learners tend to choose independent modules to complete tasks according to their own learning conditions, rather than contact with deeper peer relationships. In addition, peer relationship will promote learners to form better creativity in game-based learning. Sousa & Rocha's (2019) research shows that game-based learning will promote students to form good learning motivation and learning mentality, thus changing the communication mode in group cooperation, and forming a good virtual learning community atmosphere (Spoor & Kelly, 2004).

5.3 Learning Opportunities and Creativity

In this study, both learning time and learning cost have significant positive effects on learning opportunities, while learning frequency has insignificant positive effects on learning opportunities. Previous studies have found that teenagers tend to strengthen their creative self-concept in class (Karwowski, 2015), which in certain circumstances will lead to higher creative benefits for the learning time and cost invested. At the same time, we found that students with high learning frequency tend to use fragmented time to learn (Lenz & Nobis, 2007), and the total amount of time per week is much lower than those with less frequency, so the improvement of creativity is not significant. In addition, learning opportunities have a significant positive effect on the improvement of students' creativity. Burleson (2005) believes that learning opportunities contribute to the self-realization of creativity and learning experience. Glaveanu at al. (2020) pointed out that learning opportunities can help learners to learn knowledge more deeply, thus improving creativity and achieving self-achievement.

5.4 Self - efficacy and Creativity

It is found that self-efficacy plays a significant positive role in improving students' creativity. This is in line with previous studies. Aji et al. (2019) found through empirical research that self-efficacy, creativity and motivation have a very strong relationship with significant interest. Spoor & Kelly (2004) believes that group emotion can provide information about the environment and group members to other group members, so as to coordinate group activities through communication functions. In addition, in gamification learning, group common emotion can coordinate group activities through group bonds and group loyalty, thus generating stronger self-efficacy. When learners have a sense of self-efficacy, they will be better engaged in learning and produce more significant creativity.

6. Conclusion

Research has shown that connected learning is enhanced through the creative use of digital technologies by engaging students in game-based learning.

6.1 Research Significance

This study has certain research significance. Firstly, teachers should introduce the concept of art into game-based learning, cultivate students' artistic perception and appreciation (Brady, 1998), and creatively use digital technology to enhance interconnected learning (Gee & Hayes, 2011). Secondly, teachers should integrate group collaboration into game-based learning to promote the same common goals among learners. Successful game-based learning design requires effective teaching methods to organize collaborative teaching process (Lahti et al., 2004), in which teacher guidance plays a significant role (Øygardslia, 2018). Thirdly, schools and society should provide students with better environmental support and more learning opportunities (Monsen at al., 2014), so as to help students with poor economic conditions to have more connected learning experiences on campus and off campus. Finally, students are encouraged to participate in constructivism interconnected learning (Kafai & Burke, 2015), play a game learning maximum value, and help students have more interest in learning, concentration, the formation of self-efficacy, through the establishment of contact information environment more deeply involved in the Internet learning, help students achieve learning effective contact inside and outside class.

6.2 Research Limitations and Future Prospects

This study has some limitations that need to be addressed in future studies. First of all, the sample size of the study was very small, only 56 students completed the questionnaire, and less than half of the students had high weekly study time and high weekly study frequency. Therefore, the sample could not provide generalizable results for the broader population, and the collection scope of the research questionnaire should be expanded in the future. Secondly, the questionnaire survey is conducted in the class. Although there are researchers in charge of supervision, some learners may peek at the questionnaires of other learners and modify their own questionnaires. Therefore, the research results are easily affected by the cognitive bias of the surrounding environment, resulting in herd mentality. Finally, the factors that influence students' creativity in game-based learning need to be thoroughly investigated in the future, such as the role of learners in game-based learning and the degree of interaction in game-based learning. In addition, when conducting similar surveys, it is better to interview students and teachers to supplement the questionnaire data and provide appropriate basis for research and discussion.

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Design Methodology of Bebras Thematic Game

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Abstract: In recent years, computational thinking has gained much attention that more and more countries have implemented it into compulsory education. The design of course content has been an important task. This study aims to describe the design methodology of thematic digital game that integrates computational thinking using Bebras. This paper presents the process of how to integrate computational thinking International Bebras Challenge questions into a game by aiming the target user group, define computational thinking levels, choosing Bebras questions corresponding to teaching content, and designing storylines to form the game scenario. It can inform future computational thinking games for various age groups in different instructional contexts.

Keywords: Computational Thinking, Bebras, Digital Game-Based Learning, Game Design Methodology

1. Introduction

Technology has been widely used in the educational environment, and the change in learning tools has indirectly affected the students' perception of the learning environment, leading to consequential boredom to lecture-type instruction. In order to stimulate students' learning motivation, games are widely used inside and outside of the classrooms. For example, Hooshyar et al. (2021) used a digital game called "Auto Thinking" for the students to learn computational thinking and found that students were more willing to learn through digital games. Digital learning games normally adds strategy, quizzing, and feedback mechanisms (Rojas-Mancilla et al., 2019). Several studies demonstrated its use, for instance, Shih's (2016) integrated robots in the table game and students' coding path showed that students immerse in the games and enhance computational thinking skills. Similarly, Schez-Sobrino et al. (2020) designed a game system called RoboTIC, in which road traffic signs are embedded in a game simulation environment to demonstrate programming logic for tasks.

Although Bebras is a well-known CT activity, it is in test forms. Question-based learning might be distant and tedious to students after long-time usage. Therefore, this study aims to transform Bebras CT test questions into CT digital games to increase students' motivation. This paper illustrates the instructional design methodology with an example <Captain Bebras> so that it can be used in the future CT game design for other age groups and in various thematic contexts.

2. Related work

2.1 Bebras

Bebras Challenge is an international initiative aiming to promote Informatics and computational thinking (CT) among school students at all ages, but later was used and as tests that refers to the ability to think through a problem to come up with a solution or to understand it more clearly (Selby et al., 2014). Bebras was initially proposed by Valentina Dagienė of Vilnius University in 2004, Lithuania. Bebras means "beaver" in Lithuanian and are known as "nature's engineers" because of their habit of cutting wood, digging ditches, and using branches and soil to change the environment around them. Therefore, Bebras expects

students to be as versatile as beavers in solving life problems, so most of the questions are contextualized which are classified into eight computational thinking components, namely Abstraction, Logic, Data Analysis, Decomposition, Algorithms, Simulation, Systematic
Evaluation, Generalization. Generalization. (https://www.bebras.org/)

All students of the right age can sign up for the Bebras Challenge through their teachers' classes. Taiwan first joined hosting the Challenge in 2012, and in only a few years, it has attracted 511 teachers leading 217,640 students in 2020.

In order to promote the learning of computational thinking to younger students, Bebras categorizes questions into levels in terms of age groups. For example, Benjamin refers to the 5th and 6th grade group, and Cadet refers to the 7th and 8th grade group. It shows a general atmosphere of recognizing computational thinking to be a skill that needs to be developed in the young age.

2.2 Digital Games

A good teaching process requires not only appropriate materials but also active participation of learners to produce better learning outcomes. Digital games have been shown to have strong motivational factors that can stimulate learners' motivation (Laine & Lindberg, 2020). In addition to the interesting and fun features, game design must also consider how to visualize the physical learning content, so that the concepts that are expressed or explained in the traditional classroom can be expressed in the virtual world. In order to strike a balance between educational design and game design, a designer with rich experience in both fields is needed to successfully complete the project (Viudes-Carbonell et al., 2021).

Game design often requires the construction of a virtual world in which players can quickly adapt to learning, so the design of the game context becomes important. For example, the use of up to 13 game scenes can lead to a physical teaching environment (Frossard et al, 2019), or the use of a "videogame storyboard" to create a virtual story that simulates reality (Moreno-Ger et al, 2007). To motivate learners, it is necessary to establish game scenes, where multiple scenes and stories can engage learners to participate more actively. Game design must also be challenging, and the concept of game theory applies to digital games (Taylor et al, 2019), meaning that the game needs to increase in difficulty as the scenario progresses, while the player can gradually adapt to higher levels of play through the experience gained in the previous level.

Finally, game designers should observe whether the learning content and game elements of digital games are smoothly integrated and balanced based on the system records of players' play (Hong et al, 2009), and design more adaptable game play based on experience in the future (Taylor et al, 2019).

3. Game Design Methodology

3.1 Define Student Participants

To design a game, first is identify the target audience and its age group before defining the game difficulty level. Observing the number of participants in the Bebras Challenge over the years, it is found that the Cadet group is the fastest growing and most popular group at present. It can be a good lead-in to start design game-based Bebras to attract the students to enhance their CT skills. In Bebras, each test question has clear identification of its difficulty level corresponding to its grade level with CT ability values. However, to design thematic games, it is not possible to include all the questions and sometimes need to mix levels.

This study choose Cadet Group as the target age group of the thematic game <Captain Bebras>.

3.2 Select Appropriate Questions

Bebras questions can be scattered on the Internet since there are many scholars and teachers participating it, among which the officially certified Chinese versions are the 2016 and 2017 tests (*Figure 1* and *Figure 12*). There are 15 to 20 questions in three difficulty levels for each of the four age groups, namely Benjamin, Cadet, Junior, and Senior. Other than that, it can be helpful to use "Bebras Discover Computational

Thinking" (*Figure 3*) to start with which details the eight types of computational thinking and the categorization and interpretation of the questions summarized by Bebras. Each Bebras question was tagged with algorithm keywords linking to the computational thinking test. It is easy for designer to search and align questions for thematic storylines. A table of contents lists (*Figure 56*) all the eight components with informatics concepts at a glance.

In <Captain Bebras>, the team selected six questions for the Cadet age group with the alignment of CT competency and categories with keywords (Figure 5). For example, the Bebras question used in Task 5 of <Captain Bebras> (*Figure 34*) is about "Euler Circuit" and "Graph" with the corresponding CT competence "Data Analysis" and "Systematic Evaluation".

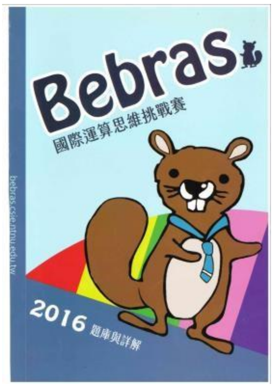

Figure 1. 2016 Bebras Challenge Questions

Figure 2. 2017 Bebras Challenge Questions

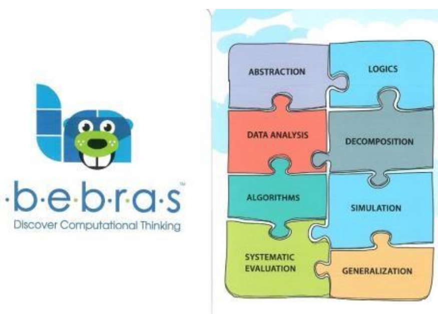

Figure 3. Bebras Discover Computational Thinking

*Figure 4.*One of the 2016 topics

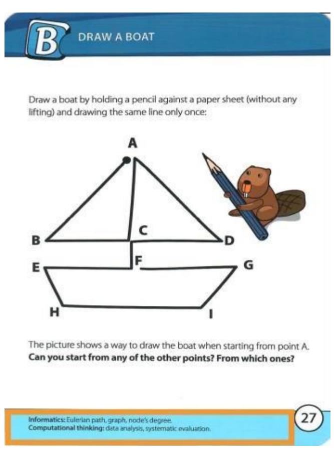

Figure 5. Bebras question & CT

Figure 6. Bebras CT classification list

3.3 Draft Thematic Context

This study proposed three steps to integrate Bebras CT questions into digital game design.

The first step is "Determine Story Theme". Designers should draft a clear chronological story background. The context can be in the past, in the future, real, or fictional. Set up a time interval for the story can help the arrangement of game missions. In <Captain Bebras>, the Great Voyage time is chosen so the storyline is related to sailing. Related historical events should be determined for arranging game missions later.

The second step is "Determine Player's Role". The role in the storyline guides the player through the game. Every decision the role makes (answer to Bebras questions) will lead to different game feedbacks and affect the value to proceed the following missions. For example, in <Captain Bebras>, the student play the role as Magellan, the famous navigator in the Age of Discovery. As the captain of the fleet, the player tries to complete the missions.

The last step is "Define Game Goal". Instead of solving individual CT questions, the player has a final goal to accomplish so they would try hard to pursue the final game goal. In <Captain Bebras>, the player need to earn certain amount of money, decide to buy chosen goods, and distribute goods to various locations for tribute, etc.

3.4 Design Thematic Missions

With the storyline, the game stages can be designed to comprise missions. It is suggested to align missions with CT levels from low to high so that the players would progress gradually instead of facing hurdles and want to give up. In <Captain Bebras>, there are five stages in the game, and each stage embeds a mission with the corresponding CT competency (*Figure 7*). When the player completes all missions, he learns all eight CT components. The player can repeat the same mission until he passes.

Mission One	**Mission Two**	**Mission Three**	**Mission Four**	**Mission Five**
Algorithms Systematic Evaluation	Logic Algorithms Simulation Abstraction Generalization Systematic Evaluation	Abstraction Decomposition Systematic Evaluation	Algorithms Systematic Evaluation	Simulation Data Analysis Systematic Evaluation

Figure 7. Mission and CT

When designing the missions, "Level", "CT", and "Story" are suggested to be decided in order. Three missions of <Captain Bebras> are described to illustrate the process.

The first mission of <Captain Bebras> (*Figure 8*) is Treasure Map. (Level) Simple level is chosen to give students an easy start up. (CT) Since Bebras question chosen to use in this level is to use direction codes to draft a route through the forest, a maritime story about coding, directions, routes is searched. (Story) Captain Bebras uses the treasure map to walk through the forest. Players need to use the clues given to find treasure.

Figure 8. Task 1

The second mission of <Captain Bebras> (*Figure 9*) is Spice Route. (Level) To increase the complexity of game, two simple level questions are chosen for use together. (CT) The keywords regarding "maze" and "order" are mentioned in the questions so related story about search spices in correct order is drafted. (Story) Using the hints obtained from the previous mission, students choose the correct maze map according to the spice trade order.

Figure 9. Task 2

The third mission of <Captain Bebras> (*Figure 10*) is Spice Trading. (Level) To increase the difficulty level of game, a question of the intermediate level is chosen. (CT) The keywords of the question permutation and weighing in which players need to arrange the bottles with criteria. (Story) The captain needs to measure his limited budget, buy spices from countries that has lowest price.

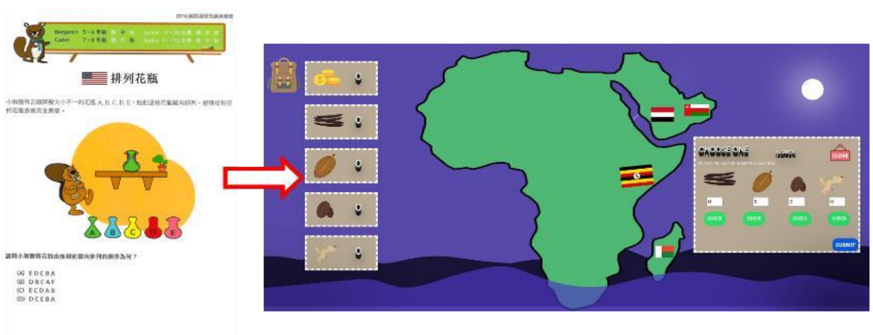

Figure 10. Task 3

4. Conclusion

The study aimed to provide the design methodology for Bebras Thematic Game with the example of <Captain Bebras> so that it can be used in the future CT game design for other age groups and in various thematic contexts. It is hoped that the students can be motivated to learn, and enhance CT competencies at the same time.

Students' gaming data in the online game system will be documented and analyzed to measure their learning effectiveness, CT skills from the mission completion speed and correctness. During the game, learners will be given the Bebras Challenge tests to determine their CT competencies by comparing to the gaming records.

Acknowledgements

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Personality Matters? Learning Behavior Analysis of Complex Board Game

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Abstract: Games can enhance students' learning motivation and performance, but students with different personality traits would have different learning behaviors and emotional responses in the game. In order to dissect the learning effects of games from the perspectives of personality traits, this study developed a complex board game, <Misu'ayaw Tayal>, based on the historical events of Tayal aboriginal tribe which uses interactive multimedia to support and extend learning experiences. A corresponding digital system is developed to document students' gaming behaviors so that the students' learning behaviors and gaming emotions can be analyzed. The goal of this study is not only to investigate the impact of personality traits to gaming, but also to construct an instructional design for historical thinking, as well as to increase students' multiple perspectives to historical events.

Keywords: personality trait, complex board game, learning behaviors, game-based learning, Tayal, AR

1. Introduction

1.1 Research goal

Board games are popular learning tools recently since games can enhance students' motivation and convey knowledge to students (Shih et al., 2017). Nowadays, students learn beyond textbooks, and internalize new knowledge through multimedia, internet, and games. Therefore, board games are gradually applied in various disciplines, such as <Element Enterprise Tycoon> (Chen, 2021) is about chemistry in which students solve problems regarding chemical processes and the use of chemical products; <Anatomy Adventure> (Anyanwu, 2014) is designed to reduce the pressures associated with the study of anatomy; and <Diplomacy> (Mattlin, 2018) is to enhance active learning to international relations. With the advancement of technology, some physical board games were transformed into digital board games or combined with technological elements (e.g. Lin & Shih, 2016). By doing so, the content of the game scenario and game functions can be extended. Nevertheless, students' gaming experiences, game effectiveness, learning behaviors, and gaming emotions depend on various factors, such as players' personality traits (e.g. Ehrler et al., 1999). Specifically, emotion is essential to the structure of personality, and the conflicts and crises accompany the development of personality traits (Keltner, 1996). Thus, personality traits have reciprocal relations with emotions and behaviors. Hence, this study aimed to investigate emotions and behaviors from the perspective of personality traits.

This paper presents a complex board game <Misu'ayaw Tayal> about Tayal historical events integrating interactive multimedia using Quick Response Code (QR code). Twenty elementary school students will be invited to participate the instructional practice. The aim of the study is not only to convey historical knowledge in order to let students understand what Tayal has experienced in the past but also to make them examine the historical events from multiple perspectives.

1.2 Research question

In this study, students are asked to role-play the historical characters and cooperate with others to solve the problems in each historical event. The research questions for this study include:

1. How student with different personality traits behave differently in <Misu'ayaw Tayal>?
2. How student with different personality traits emotions change in <Misu'ayaw Tayal>?

2. Related Work

2.1 Complex board game

Many previous studies showed that games are an essential and innovative learning tools in the education setting. For example, Eltahir (2021) used Kahoot! as formative game-based assessment tool in the course. They divided the students into two groups, one group learned with traditional strategy and the other group learned with Kahoot!. The results indicated that the group with game-based learning showed high motivation and had better learning performance. Among all kinds of games, board games have gradually emerged in the field of education and become popular. Board games refer to physical games using boards placed on a flat surface without the need to plug in electricity. There are also many kinds of table games, i.e., card games and dice games, that do not involve boards. Board games can be designed to convey and suffice different knowledge fields. Previous studies have shown that board games can positively benefit to enhance active learning (Yoon et al., 2014) and improve learning performance (Cardinot & Fairfield, 2022; Luchi et al., 2019). In addition, some researchers incorporated cooperative learning methods with the board game in the reaction engineering course that provoked students' thoughts and improved their teamwork skills (Azizan et al., 2018).

With the rapid development of technology, more and more technological elements are integrated with board games to extend the context of the game as well as gaming functions so that students can be more immersed in the game scenario and the gaming process. Such technology-enhanced game is defined as complex board game (Lin & Shih, 2021) which allows students to experience a mixed realities gaming environment. For instance, Lin and Shih (2016) designed a complex board game which presented a pop-up map tagged with near field chips (NFC) that triggers extended digital information and gamified interactions through smartphones. Subsequently, Sukernasa, Shih and Surjono (2020) implemented the technology-mediated board game to engage Indonesian learners to learn English vocabulary. Students scanned the QR code at the back of cards to interact with English learning questions. In the same year, Hsu and Lee (2020) integrated AR in a sequential social story situation board game. Such a system consisted of different social situation judgement tasks. Autistic children learned to distinguish decisive priority and to appropriately respond to others in the given situations. The results from this study showed that the game can greatly improve students' motivation and gaming pleasure. Through the integration of technological elements, players can not only immerse themselves in the game environment but also acquire knowledge. Therefore, this study attempts to design a complex board game that combined a physical board game and interactive multimedia using QR codes. The content of the game was related to Tayal and foreign ethnic groups. Students should scan the QR code to obtain information related to historical events.

2.2 Personality traits

As mentioned above, games could effectively enhance students' learning performance as well as learning motivation (Chang et al., 2018; Yeh et al., 2017). In addition to such positive effects, previous studies showed that personality traits could affect students' perception toward various game elements (Denden et al., 2021). Personality traits refer to psychological characteristics, serving as essential predictor of many outcomes (Parks-Leduc et al., 2015). To gain insight into who people are, personality tests have been used to understand personality traits in various settings, including workplaces and schools. For years, a wide variety of personality tests have been developed. Each personality test has a different classification of personality traits. There are some popular personality tests, such as Big Five personality traits, Myers-Briggs Type Indicator (MBTI), and Eysenck Personality Inventory (EPI). Among them, Eysenck Personality Inventory (EPI) (Eysenck, 1964) was developed in the beginning with only two dimensions, i.e., Extroversion/Introversion and Neuroticism/Stability. These two dimensions have been found to associate with positive and negative emotionality respectively and such differences in these traits are considered to affect emotional and cognitive processing (Kehoe et al., 2012). Since Eysenck Personality is inextricably linked to emotions, it is chosen to be employed in this study as the design foundation to verify whether personality traits influence gaming emotions.

There are three dimensions in the Eysenck personality inventory with N, E, and P values.

- ★ Neuroticism/Stability (N): The value of N stands for emotionality level of individual. People with high N score tend to be emotionally unstable, nervous and irritable while people with low N score tend to be less reactive and calmer.
- ★ Extraversion/Introversion (E): The value of E was determined by observed behavior tendencies (Eysenck, 1968). High score indicates an extroverted personality tendency, including sociable, adventurous, emotional. Low score shows an introverted personality tendency and silent.
- ★ Psychoticism (P): The value of P represents a sensitivity level to psychosis disorder. People with high score tend to be lonely, difficult to adapt the external environment so hard to get along well to others. In contrast, people with low score favor to be mannered, get along well with others, and adapted to the external environment better.

According to Eysenck's personality theory, the two dimensions of Neuroticism and Extraversion forms four personality categories including melancholic, choleric, phlegmatic, and sanguine. Since psychosis disorder is not the educational focus in this study, only two dimensions were used. The four personality categories were employed in the design of the interactive emotional responses in the game system so students' choices in the game can be analyzed accordingly.

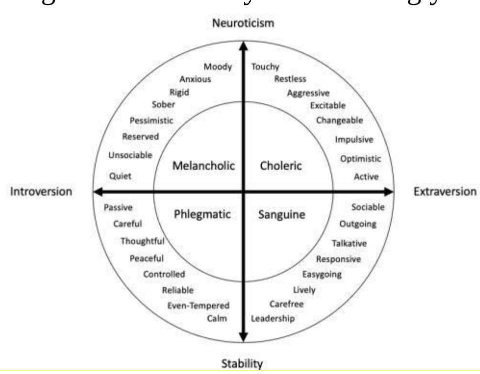

Figure 1. Personality categories of Eysenck's personality theory

3. Game Design

3.1 <Misu'ayaw Tayal>

Misu'ayaw stands for "Go ahead" in the Atayal language. The name implies Tayal's bravery and insistence when they experienced persecution by foreign ethnic groups, they still look forward to the bright future. The precursor of <Misu'ayaw Tayal> was <Mosa Tayal> which is a physical territorial board game with a map board, cards, resource symbols, bargaining chips, and dice. In this study, <Misu'ayaw Tayal> was developed by adding interactive multimedia based on <Mosa Tayal> to make students understand the historical events related to Tayal and foreign ethnic groups. In <Misu'ayaw Tayal>, every historical card comes with a QR code that leads to interactive multimedia of storytelling and action options. Thus, this game not only allows students to play and interact with peers face-to-face in the physical setting but also facilitates students to think about the positions they take toward various events, and see historical events in different light as a game character. To complete the game, students have to communicate, negotiate, and coordinate with others to resolve the intergroup conflicts.

There are five roles in <Misu’ayaw Tayal> including Han Chinese, Japan/Qing Dynasty, Tayal 1, Tayal 2, and Tayal 3. Students choose roles to play. The winning conditions include the increase of total resource values, and reach consensus to all the conflicts generated in the historical events by all the ethnic groups together. The results are defined by participants including the teacher/game master.

3.2 Game design

To enhance students' understanding of the historical events and to increase the interaction and enjoyment of the game, every role in the game comes with different sizes of population, level of civilization, amount of fortune, resources, and power of defense at the beginning (Figure 2). All the ethnic groups should expand their territories to progress the game. Five historical events are presented in the respective round in the game (Figure 3), namely the migration of the Tayal tribe, the civil unrest, Msbtunuxd Incident, the period of Japanese occupation, and the Bnqcip Incident. All historical events involve conflicts between different ethnic groups that require them to negotiate and reach consensus to the final conflict resolution. Take the third event Msbtunuxd Incident as an example, after Liu Ming-Chuan implemented Mountain Development and Aborigines Pacifying Policy, Qing Dynasty and Han Chinese started to plunder the camphor recourses from the Tayal tribes. Because of the strong force attacks, Tayal 2 surrendered while Tayal 1 and Tayal 3 struggled to resist. The situation is quite tensed so they have to decide whether to negotiate with Qing Dynasty and Han Chinese or to foster wars to protect their resources. Decisions can be made by the students during the game.

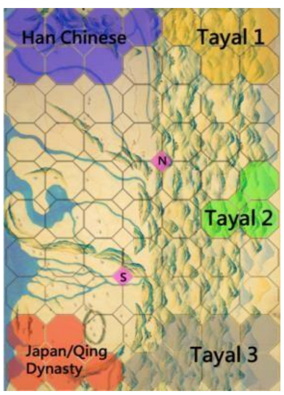

Figure 2. Map of the game

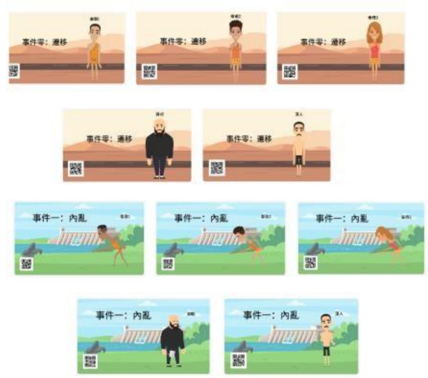

Figure 3. Historical event card of the five ethnic groups

3.3 <Misu’ayaw Tayal> Game System

All historical events are presented by the interactive media in the game system. Unity, a cross-platform game engine, is used for the development. Android is used as the main publishing platform in this study.

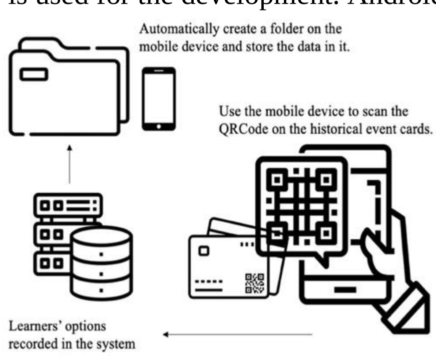

Figure 4. System architecture

Figure 5. Animation and decision-making choices

Two major functions were developed for <Misu’ayaw Tayal>: showcase the historical event animations, and interactive decision-making choices. As shown in Figure 4 and 5, during the gaming process, students scan the QR codes on the historical event cards and the corresponding historical event animations will be played on the mobile devices. The scenes, effects, and roles of the animations were created by Animaker and imported into Unity to make students more immersed in the game scenario. Besides, each animation is different according to the roles. Decision making choices were given at the end of each event animation. Every option to the question is an emotional response prescribed based on Eysenck personality theory, corresponding to the four personality categories of melancholic, choleric, phlegmatic, and sanguine respectively. Students choose the option that best fits their emotions and choices in the situation. For example, the question in the first event The migration of Tayal is “What should we do? Our land is not enough”. The four choices are “Don’t worry, there will be a way.”
(sanguine), “We’re done.” (melancholic), “I know. It’s quite annoying.” (choleric), and “It’s not serious at all.” (phlegmatic). Choices made throughout the game would lead to certain affects or outcomes in the later events, such as deduction to resources in the physical game. For instance, students who made repetitive emotional options of sanguine will gain an additional resource, while repetitive emotional options of choleric will lead to loss of resources. All emotional options selected by the students are recorded. At the end of the system, a folder is automatically created in the device to store the data in.

4. Research Design

4.1 Research process

This study will be conducted in an elementary school in Taiwan with 20 students. All the students will be divided into four groups with five students in one group. As shown in Figure 6, the research started with a questionnaire with 12 questions to collect students’ personal information and their gaming experiences playing board games. Then the students will be asked to take the Eysenck Personality Inventory (EPI) to identify their personality traits. The complex board game will take about 60 minutes. During the gaming process, the students experience 5 historical events and play toward their own goals. After the game, they will take a game satisfaction survey that consisted of different aspects. Such survey will be employed to collect students’ feedbacks to the game.

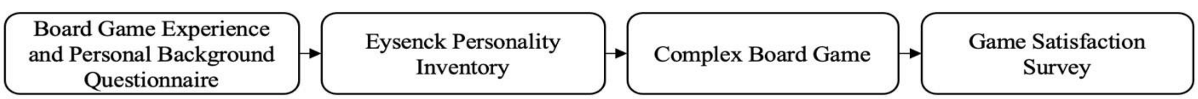

Figure 6. Research process

For EPI, every chosen answer to a question would add in a point to the related scale of the corresponding dimension. The T score (T=50+10*(X-M)/SD) was converted according to the total score in each dimension. Students with different personality traits will be divided into groups in the most heterogeneous way so the students can interact with peers with different personality traits.

4.2 Research tools

To answer research questions, research tools are employed in this study.

★ Board Game Experience and Personal Background Questionnaire: The questionnaire comprises two parts. The first part is to collect the basic information of students, including age, gender, favorite subject, etc. The second part is to investigate students’ game preferences and experience. ★ Eysenck Personality Inventory: It is employed to identify the personality traits of each student.

There are two scales in the inventory, Extroversion/Introversion(E) and Neuroticism/Stability(N).

★ Learning Behaviors Observation Sheet: It is conducted to document students' gaming behaviors. All gaming behaviors will be coded and analyzed to know the influence of personality traits.
★ Database record: It is used to record students' decision-making choices related to emotional responses while facing problems in the historical events.
★ Game Satisfaction Survey: The survey aims to measure students' game satisfaction in seven dimensions, namely aesthetics, availability, enjoyment, freedom, game process and learning.

5. Conclusion

Nowadays, genres of board games have become more diversified especially with the advancement of technology. Gradually, many board games have been applied to embed knowledge. With the board game <Misu'ayaw Tayal>, historical thinking can be naturally stimulated. By integrating technological elements into physical board games, students are able to learn about historical events while having fun. During the process of having conflicts and making cooperation, students learn how to negotiate with others and to solve problems. However, personality traits are one of the human factors that influence students' behaviors during the game. Individual differences would influence decision making, emotions and perspectives, as well as gaming strategies and behaviors. This study focused on the examination of the behavioral differences and emotional changes of the students from the perspective of personality traits. The results of this study will help future researchers to develop more inclusive educational game designs and give the history education a new look.

Acknowledgements

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The Development of Ethoshunt™ to Transform Teaching and Learning Practices of Counseling Ethics Education

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Abstract: Ethics incorporate the sources of human standards and values. However, there is a consistent struggle to locate both concepts of social condition and human values; and the question of what comprises counseling ethics education is complex and intriguing. Therefore, there is an urgency to transform teaching and learning practices of counseling ethics education by integrating educational gamification to complement the conservative classroom teaching and learning methods. A prototype called Ethoshunt™ is developed from gamification ideation as an educational gamification-based app that can be utilized in teaching and learning of counseling ethics education. The elements of game dynamics, game mechanics, functionality, and learning flow of Ethoshunt™ emerged as unique aspects which enable the students engrossed with learning objectives and charted with learning outcomes, digitally. The researchers advance that Ethoshunt™ may bring a new gamut of talent for educators in developing technology-mediated learning to augment teaching and learning activities in counseling ethics education. Ethoshunt™ holds the potential to inspire students while making counseling ethics education learning more fun and enjoyable. This offers possibilities to revolutionize existing counseling ethics education teaching and learning practices in line with the needs of the 4th Industrial Revolution.

Keywords: Ethoshunt™, educational gamification, counseling ethics education, teaching and learning

1. Introduction

We have been observing rapid technological and science advancements (Chowdhury, 2016); and recently, the 4th Industrial Revolution is profoundly influencing our ways of living and every other aspect of our lives (Wang, 2021). The 4th Industrial Revolution has modified the global sociological model (García-García et al., 2020) and how does sociological function. This new wave of transformations implies the use of various advanced technologies embedding the use of internet widely to support technologies (Schumacher et al., 2016). Intelligent machines with human actors are integrated in the new industrialization era to increase economic efficiency, reduce manufacturing costs, improve labor productivity, and return on investments (Sima et al., 2020). On the other hand, Fox et al. (2020) referred the 4th Industrial Revolution as quantum industry, which is detailed, complex, and challenging.

According to Fox et al. (2020), quantum technologies offer remarkable advantages as compared to existing technologies. However, optimization of current job role and self-equipped with necessary skills are crucial to ensure acceleration of quantum technologies-related commercialization (Fox et al., 2020). Global development has witnessed three major transformations prior to the inception of the 4th Industrial Revolution (Alam et al., 2020). The three major paradigm transformations are agriculturalization, followed by weaponization and industrialization (Alam et al., 2020). The 4th Industrial Revolution which is also known as the era of intervention and incorporation of technology consists of four fundamental parameters which are: (a) digitalization; (b) cyberization; (c) webization; and (d) artificial intelligence (Alam et al., 2020). Simulation, cloud computing, big data, Internet of Things (IoT), 3D printing, virtual and augmented reality, smart sensors, and drones are examples of key technologies of 4th Industrial Revolution. The key technologies of 4th Industrial Revolution includes gamification. These contemporary technologies can be integrated to multidisciplinary platforms including education. The key question that is addressed in the current study is how does one of the key technologies which is gamification transforms teaching and learning of counseling ethics education?

According to Md Khambari et al. (2021), educators worldwide are encountering challenges to continue providing quality teaching and learning practices, in both virtual and physical settings. The responsibilities of meeting the millennials' expectations and keep them engaged during classes could be challenging too. Hence, in line with the advancement of technology, it is essential to integrate new tools and technology incorporating game elements to extend learning while promoting cognitive and emotional development of the students. The application of game elements such as game mechanics, game components, game dynamics, and game aesthetics with the support of virtual learning environment (VLE) is commonly known as gamification and it offers more advantages to human beings.

Gamification refers to the use of game-like concepts to engage students in learning (Zakaria et al., 2020a). However, gamification involves non-gaming systems (Zolfaghari et al., 2021). Rewards, goals, badges, and leaderboards are the most commonly used gamification elements (Zakaria et al., 2020a; Zakaria et al., 2020b; Zolfaghari et al., 2021). Past studies have studied on the utilization and integration of gamification is various disciplines. For instance, Alsawaier (2018) has conducted a general study to investigate the effect of gamification on motivation and engagement, Klock et al. (2021) have studied gamification in freight transportation, and Pasca et al. (2021) have synthesized gamification knowledge in the field of tourism. Shifting towards benefits and contribution, gamification has remarkably benefited human being and proven crucial in various disciplines.

Canio et al. (2021) found that shopping gamification indirectly influenced shopping engagement through the usage of a mobile app. On the other hand, Bitrián et al. (2020) found that gamified sports apps satisfy basic psychological needs of individuals such as relatedness, autonomy, and competence. Maturo and Moretti (2018) have analyzed the role of gamification-based health apps to promote medicalization. According to them, gamification or the use of gamified self-tracking transforms tedious tasks into pleasurable activities which eventually increases productivity without oppressing the individuals. Hence, gamification has huge potential in making significant improvements in all aspects of our lives including education. The primary objective of employing gamification in learning environments is to create new learning environment, increase student motivation, keep them engaged, and consequent learning outcomes (Legaki et al., 2020; Zakaria et al., 2020a; Zakaria et al., 2020b). Gamification-based applications users would also demonstrate positive learning behaviors and the application reinforces human behaviors. Furthermore, gamification allows student to learn with energized focus (Garcia-Sanjuan et al., 2018), improves motivation level (Chung et al., 2019; Hsu & Chen, 2018), challenges students with high ability (Tsay et al., 2018), promotes flexible learning environment (Tsay et al., 2018), and maintain positive attitudes toward the program or course of study (Davis et al., 2018).

Similarly, the current study introduced Ethoshunt™, an educational gamification-based mobile app as a tool which can be utilized in teaching and learning of counseling ethics education. Past studies have revealed significance of gamification in mental health and well-being (Cheng, 2020; Fleming et al., 2017; Six et al., 2021), multicultural counseling (Mzohd Daud et al., 2019), and emotional health treatment through Cognitive Behavioral Therapy (CBT) (Christie et al., 2019). Similar to Ethoshunt™, Suhaimi et al. (2018) has applied gamification in teaching and learning. The researchers conducted literature search and found that gamification in counseling is still at infancy stage. We found limited gamification-related resources in counselor education.

In this study, the technical components of Ethoshunt™ were published in Zakaria et al. (2020a). Ethoshunt™ was mainly developed to complement the existing counseling ethics education teaching and learning practices. Currently, the counseling ethics educators are utilizing traditional teaching tools such as whiteboard, presentation slides, textbooks, and online resources. Changes are required specifically in the teaching and learning of counseling ethics education as ethics education is a cut and dry course (Carnes-Holt et al., 2016; Subarimaniam et al., 2020; Warren et al., 2012; Zakaria et al., 2022).

Ethics incorporate the sources of human standards and values. However, there is consistent struggle to locate both within concepts of social condition and human values; and the question of what comprises counseling ethics education is complex and intriguing (Levitt et al., 2015; Mullen et al., 2014; Zakaria et al., 2013). Furthermore, there is lack of proper and clear solutions to the counseling ethical issues (Hill, 2004; Zakaria, 2013; Zakaria & Warren, 2016; Zakaria et al., 2017). Therefore, there is an urgency to transform teaching and learning practices of counseling ethics education by integrating educational gamification to complement the conservative teaching and learning methods. According to Zakaria et al. (2020b), gamification is used in various focus areas and guarantees technology advancement in many sectors. They also found that one of the most recurrent target users of gamification are students. They have highlighted that one of the probable hubs of gamification could be education sector. Hence, it is worthful to explore Ethoshunt™. The researchers believe that the new educational gamification-based tool could be more amuse and immersive with experiential-based learning features.

2. About Ethoshunt™

A prototype called Ethoshunt™ is developed from gamification ideation as a tool which can be utilized in teaching and learning of counseling ethics education. This educational gamification tool is developed not to replace; but to complement the existing conservative teaching methods utilized in counseling ethics education. The elements of game dynamics, game mechanics, functionality, and learning flow achieved through Ethoshunt™ emerged as unique aspects which enable the students engaged with learning objectives. Furthermore, Ethoshunt™ ensures that students are charted with learning outcomes, digitally.

The system architecture of Ethoshunt™ was designed to handle few types of interfaces which are Android mobile app, desktop web browser, and mobile web browser (Zakaria et al., 2020a). For desktop web browsers, the system has been pilot tested via Safari (Apple; Version 11.0.3) on Mac OS X EI (Apple; Version 10.11.6) and Google Chrome (Version 74.0.3729, official build; Google) on Windows 10 (Microsoft). For mobile web browser and the Android mobile app, the system was tested using Google Chrome (Google; 74.0.3729.157) and (Google; Version 9.0) respectively. Figure 1 depicts the gamification-based mobile application being used by a postgraduate student for her counseling ethics education course and Figure 2 shows the features of the app.

Figure 1. Gamification-Based Mobile Application, Ethoshunt™

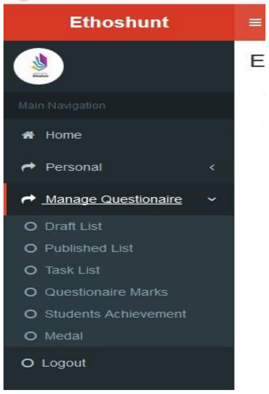

Figure 2. Features of Ethoshunt™

3. Methodology

The development process of Ethoshunt™ is a three-stage plan that involved taking the mobile app from initial concept to final launch in the classroom. The initial concept and final launch focus on the content of the gamification-based mobile app. This process excludes the development of system architecture, market launch, and securing of intellectual property of the innovation. The first stage of Ethoshunt™ development process is the identification of game mechanics, followed by identification of game dynamics and launch in the classroom.

2.1 Stage 1: Game Mechanics of Ethoshunt™

Game mechanics is a mechanism that encourage certain behavior or move the simulation forward with the help of rewards and example of game mechanisms are points, levels, and badges (Blohm & Lelmelster, 2013). Ethoshunt™ functions based on the four steps as shown in Figure 2. First, the instructor will send hints related to counseling ethics to the students. Students are required to check the hints sent by their instructor and in response to the hints, students will need to submit an appropriate answer for evaluation or grading purpose. The hints and answers must be within the scope of counseling ethics education; and can be in the form of audio, image, text, or video. Points will be given to each correct answer.

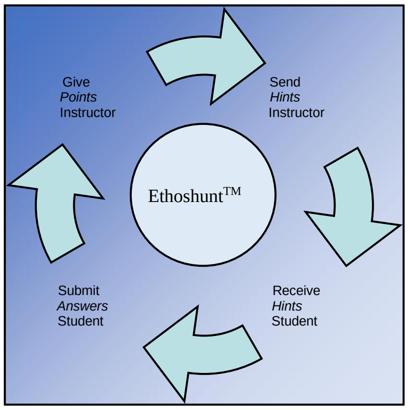

Figure 2. Game Mechanics of Ethoshunt™.

2.2 Stage 2: Game Dynamics of Ethoshunt™

Game dynamics reveals the effect of game mechanics (Blohm & Lelmelster, 2013) and how user of the gamification-based mobile app evolves over some time. Game dynamic include feedback, time pressure, and progress. Ethoshunt™ is integrated with progress-based game dynamic. The users or students will progress through multiple levels and the final level would indicate highest level of understanding of counseling ethics education. Students who have mastered the course would score more points and have higher tendency to reach the final stage of Ethos levels (See Figure 2).

2.3 Stage 3: Launch of Ethoshunt™ in the Classroom

The launching of Ethoshunt™ was held in a smart classroom located at the Faculty of Educational Studies, Universiti Putra Malaysia. The researchers performed user acceptance testing to test the interface and function of Ethoshunt™. The user acceptance testing involved students who have registered for the counseling ethics education course. The user acceptance testing was performed based on the following steps:

Send Hints (Instructor):

Hint	:	What does a counseling ethical decision-making model looks like?
Instruction	:	Upload an image as your answer to the question. The hints can be related to hidden information in the virtual or real world. The hints can be sent at any time of the day before the dateline without any restrictions.

Receive Hints (Student):

The student receives the hint from instructor through a dedicated Android app. A notification will be displayed on the student's mobile device screen. The types of hints can be hidden details in the real and virtual world. Details in the real world could be related to physical clues. On the other hand, details in the virtual world could be quotes, stories, images, audios, films, dialogues, and other internet-based particulars.

Submit Answers (Student):

The student submits an answer (an image as requested by the instructor) via the Android app. The instructor will also receive notification on the mobile device or laptop screen.

Give Points (Instructor):

The instructor gives Ethos points for correct answers. Students will progress through Ethos levels: (a) Infancy; (b) Childhood; (c) Teenager; and (d) Matured (See Figure 2). Students who have advanced to the matured level reflects good understanding of counseling ethics and ability to make mature ethical reasoning.

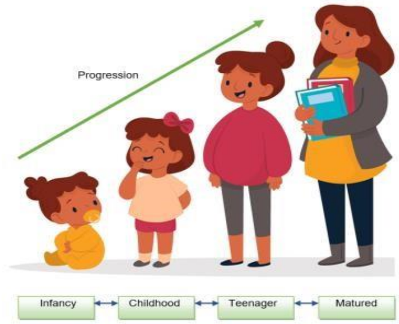

Figure 2. The Ethos Levels.

4. Results

The outcome of the user acceptance testing of Ethoshunt™ as a tool in teaching and learning of ethics education was projected through effectiveness of the gamification-based mobile application in counseling ethics education. The students advanced from one Ethos level to another Ethos level (from infancy stage to childhood stage, followed by teenager and matured stage) and target Ethos points were collected at the end of the user testing. The students took part in a meaningful ethics education learning flow (See Figure 3) consisting of 10 learning keys which was different from the conservative learning process. The 'achievement' concept motivated the students to accomplish task given by their instructor and 'appointment' refers to the students' responsibilities to check on the hints they received. The use of Ethoshunt™ in teaching and learning of counseling ethics education can be motivating and would encourage them to set goals in achieving matured stage. Next, they work 'collaboratively' with other peers while focusing on 'epic meaning'. Utilization of gamification-based mobile application can cultivate creativity and foster relationship with others specifically when it involves group work. On the other hand, focusing on epic meaning helps them to achieve excellent learning outcomes.

Students receive bonuses in the form of Ethos points for all their achievements and collect tareted points within a specific duration through 'countdowns'. Countdown refers to the number of points they have to count through until highest stage is achieved. 'Discovery' reflects how students navigate through the ethics education course and 'synthesis' knowledge gained. For 'loss aversion', the students will continue playing to avoid losing what they have gained. Finally, the students will work through 'infinite play' by being active and engaged in the learning process until they become expert in the course. Perhaps, students can continue playing until they achieve matured stage which means they have good level of knowledge in counseling ethics.

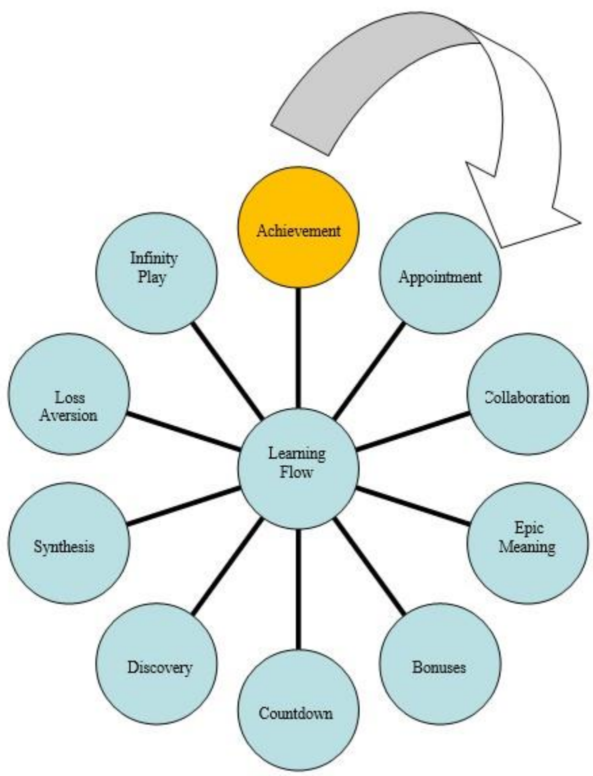

Figure 3. Learning Flow through Integrative Ethoshunt™.

5. Conclusion

As a student, discovering new knowledge and synthesizing what they have learned are part of their development. Navigating throughout the learning process can be challenging. However, integration of gamification-based tools such as Ethoshunt™ can transform teaching and learning practices of counseling ethics education into meaningful process. Securing what they have gained would reflect their responsibility level and infinite play would reflect their commitment to become expert in counseling ethics education. The researchers advance that Ethoshunt™ may bring a new gamut of talent for instructors in developing technology-mediated learning to augment teaching and learning activities. It drives motivation, fosters deep engagement, and collaboration among the students. Ethoshunt™ holds the potential to inspire students while making ethics education learning more fun and enjoyable. Furthermore, Ethoshunt™ transforms cut and dry ethics education course into meaningful contents and it can be used across disciplines. The usefulness of Ethoshunt™ offers possibilities to revolutionize existing counseling ethics education teaching and learning process in line with the needs of the 4th Industrial Revolution.

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A Computer-Supported Personalized and Collaborative Learning to Improve Professional Learners' Performance in Advanced Cardiac Life Support Training

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Abstract: The Advanced Cardiac Life Support (ACLS) training was organized to help professional learners establish basic competence in the comprehension of electrocardiograms. However, learners usually have difficulty memorizing the meanings of different electrocardiogram waveforms, which could represent clinical symptoms or even the feeling of dying, via traditional instruction. Some severe problems could lead to death if the professional staff does not make correct judgments and provide timely treatment. Thus, this paper reports an exploratory study on the effects of a computer-supported personalized and collaborative learning approach on professional learners' ACLS learning achievement. A 2-week experiment was conducted to compare the learning achievement of the following: professional learners who learned with the ACLS situation-based computer-supported personalized and collaborative learning approach, and those who learned with the ACLS traditional approach. The experimental results show that the professional staff who learned the proposed method had a better learning performance than those who learned the ACLS traditional approach.

Keywords: Decision making, computer-supported personalized learning, collaborative learning, mobile applications

1. Introduction

For the sake of medical quality and patient safety, clinicians in medical institutions around the world are required to take an Advanced Cardiac Life Support (ACLS) training course, as shown in Figures 1, which includes educational programs for basic life support, acute coronary syndrome (ACS), and electrocardiograms (EKG or ECG), to check for signs of heart disease (Chang, Chang, Hwang, & Kuo, 2019). Among these programs, EKG is an especially required course for medical staff to comprehend heart rhythm and rate, arrhythmia, atrial enlargement, ventricular hypertrophy, myocardial hypoxia, and myocardial injury from a wave chart depicting cardiac electrical conduction activity. Medical staff must have adequate expertise and skills to interpret EKGs when assessing patients' heart function (Amini et al., 2022). Basic waveforms of EKG can be categorized into critical cardiac arrhythmias (17 rhythms included) and cardiac arrest (4 rhythms included). Moreover, symptomatic bradycardia or tachycardia rhythms and the diagnosis of additional heart rhythms, such as ACS, acute pulmonary oedema, hypotension, shock, and cerebral infarct, may lead to an abnormal heart rhythm (Hu, Kao, et al., 2016). It is important for professional staff to enhance their EKG interpretative ability as it may facilitate their clinical work of monitoring patient safety, assessing disease progression, and evaluating more effective therapeutic outcomes (Hu, Kao, et al., 2016). In traditional EKG training courses, based on the philosophy of the American Heart Association, the instructors of ACLS training are able to guide medical learners in practical exercises to determine the best treatment in real time in the clinical practice aid, and to provide patients with the best care in a timely manner for their survival (Hu, Kao, et al., 2016). According to a comprehensive literature review, professional staff usually have difficulty memorizing the meanings of different EKG waveforms, which could represent clinical symptoms or even the feeling of dying, with traditional instruction (Chang et al., 2019).

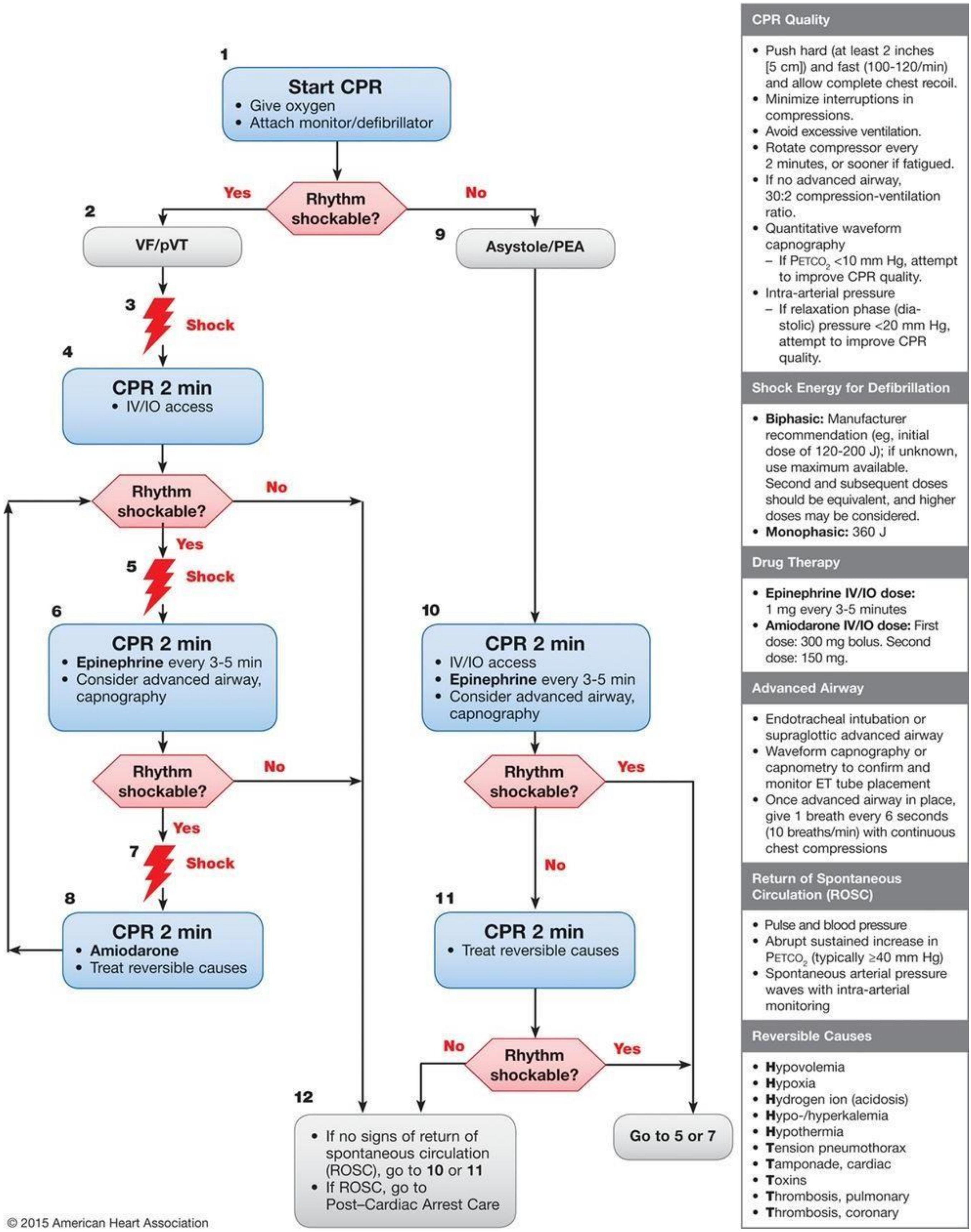

Figure 1. the ACLS process (Link et al., 2015).

Thus, this paper reports an exploratory study on the effects of the computer-supported personalized and collaborative learning approach on professional staff's ACLS learning achievement. Incorporating the computer-supported personalized and collaborative learning approach into professional learners' courses and combining situated learning strategies with digital learning systems to guide learners in reflective and deep thinking has become a new learning approach in recent years. Consequently, this study proposes a learning approach combining computer-supported personalized and collaborative learning with the situated learning strategy in an ACLS training course, which we call the ACLS situation-based computer-supported personalized and collaborative learning approach. To examine the effectiveness of the proposed approach, the following research issues are addressed:

(1) Does the ACLS situation-based computer-supported personalized and collaborative learning approach improve professional staff's learning achievement more than the ACLS traditional approach does?
(2) Does the ACLS situation-based computer-supported personalized and collaborative learning approach enhance professional staff's critical thinking regarding ACLS more than the ACLS traditional approach does?

2. Quasi experimental design

2.1 Participants

A total of 60 nursing staff with an average age of 27 years, from an academic teaching hospital in northern Taiwan were randomly assigned to two groups. The experimental group included 30 participants who adopted the ACLS situation-based computer-supported personalized and collaborative learning approach, while the remaining 30 who adopted the ACLS traditional approach were assigned to the control group. The two groups were taught by the same instructor.

2.2 Measuring tools

The measuring tools adopted in the study used a 5-point Likert rating scheme and had acceptable Cronbach's α values, ranging from .79 to .88. The questionnaires employed included the 6-item learning motivation scale developed by Wang and Chen (2010), the 7-item learning attitude scale developed by Hwang, Yang, and Wang (2013), the 9-item learning satisfaction scale constructed by Chu, Hwang, Tsai, and Tseng (2010), and the 6-item critical thinking disposition scale constructed by Chai, Deng, Tsai, Koh, and Tsai (2015). The ACLS assessment items were constructed by two nursing instructors certified by the Nursing Association in Taiwan. They consist of 20 multiple-choice items related to common EKG waveforms in the clinic, giving a perfect score of 100. The online ACLS course was established for the computer-supported personalized and collaborative learning approach, and learners were allowed to learn using their mobile devices.

2.3 Experimental procedure

First, to determine the professional staff's initial ability, both groups took the 2-day ACLS training course and completed the pre-test of prior knowledge and the pre-questionnaires, as shown in Figure 2. In the pre-class activity, learners in the experimental group were given the ACLS textbooks and were asked to preview the ACLS online multimedia material (combining videos, photos, and text) to establish basic ACLS knowledge and skills in advance. During this session, the learners did first-aid simulation exercises, such as rhythm tests, airway procedures, cardiopulmonary resuscitation (CPR), and automated external defibrillator (AED) use, as shown in Figures 3 and 4. In such a learning situation, not only could the preliminary ACLS knowledge and skills be learned, but questions about the specific operations steps of ACLS in different situations could also be proposed before the in-class activities. Therefore, the learners were able to pay more attention to the educator's explanation of the process and to self-address their questions.

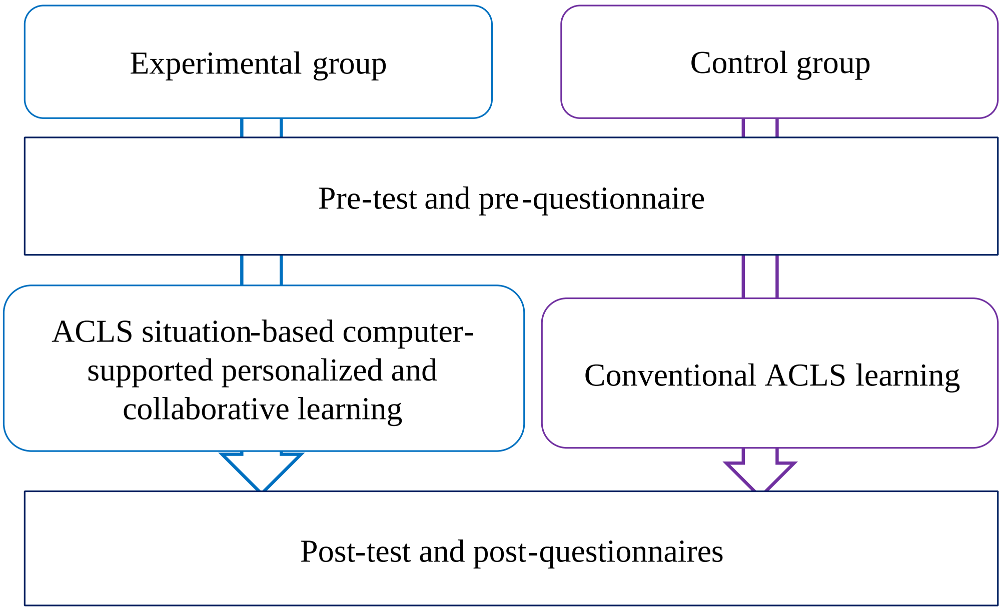

Figure 2. Experimental procedure

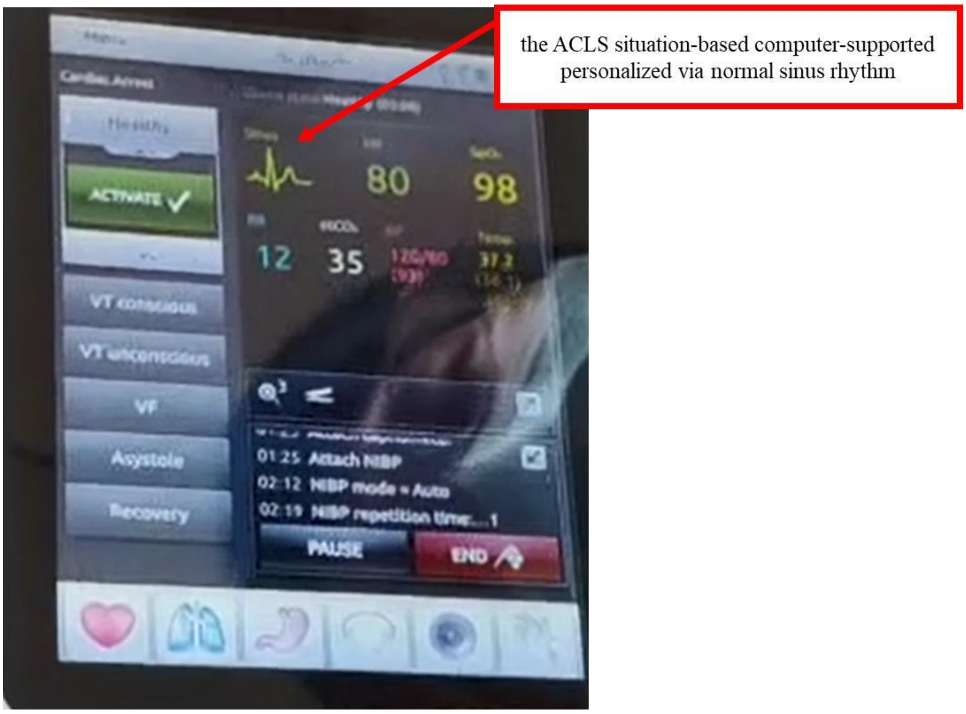

Figure 3. Screenshot of the ACLS situation-based computer-supported personalized via normal sinus rhythm.

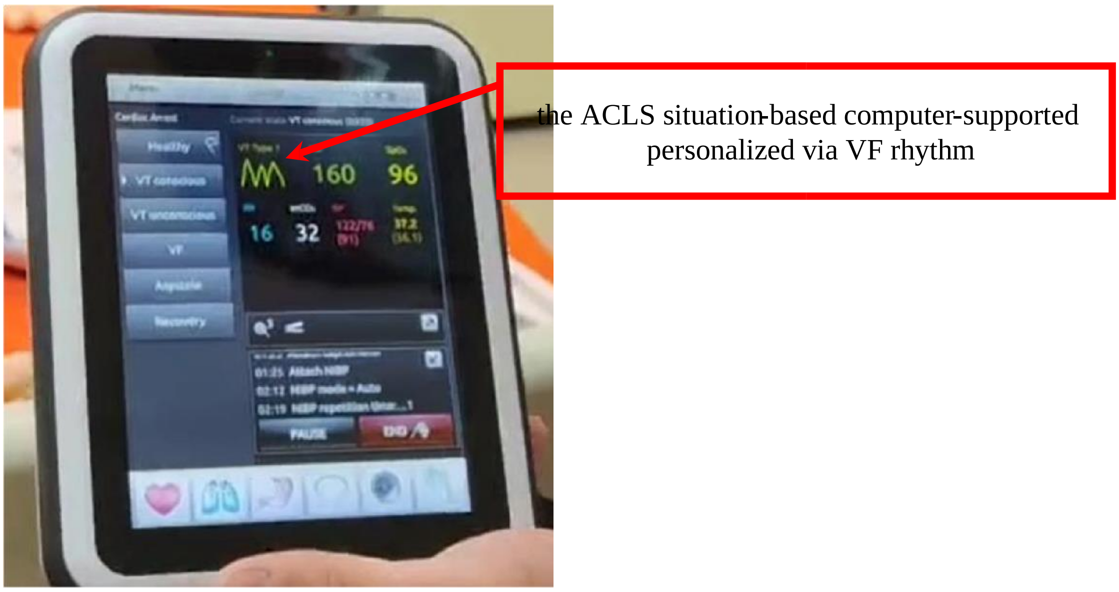

Figure 4. Screenshot of the ACLS situation-based computer-supported personalized via VF rhythm.

In contrast to the experimental group, the learners in the control group were only given the ACLS textbooks and were not asked to preview the ACLS online multimedia. During the in-class activities, the two groups were taught the same learning activities and course discussion on first aid for emergency situations. Instructors in this session addressed the professional staffs' problems with the assignments and used dummy simulations to conduct first-aid training for any emergency; these included the respiratory arrest, post-resuscitation care, CPR, ACS/acute myocardial infarction, hypotension/shock/pulmonary edema, and megacode. Learners in both groups could propose any clinical emergency problems for discussion in this session. After the in-class activity, the learners were all required to complete the post-test of learning achievement and the post-questionnaires. The multimedia material mainly introduced the key points of the on-site learning activities conducted by the teachers. The videos also presented the actual group exercises, including rhythm tests, airway procedures, CPR with AED, and megacode. The experimental group learners were able to practice the learning tasks repeatedly in the pre-class stage, thus producing the prerequisite knowledge, skills, and questions in advance of the in-class stage, as shown in Figure 5 and Figure 6.

Figure 5. Screenshot of the ACLS situation-based computer-supported personalized and collaborative learning process.

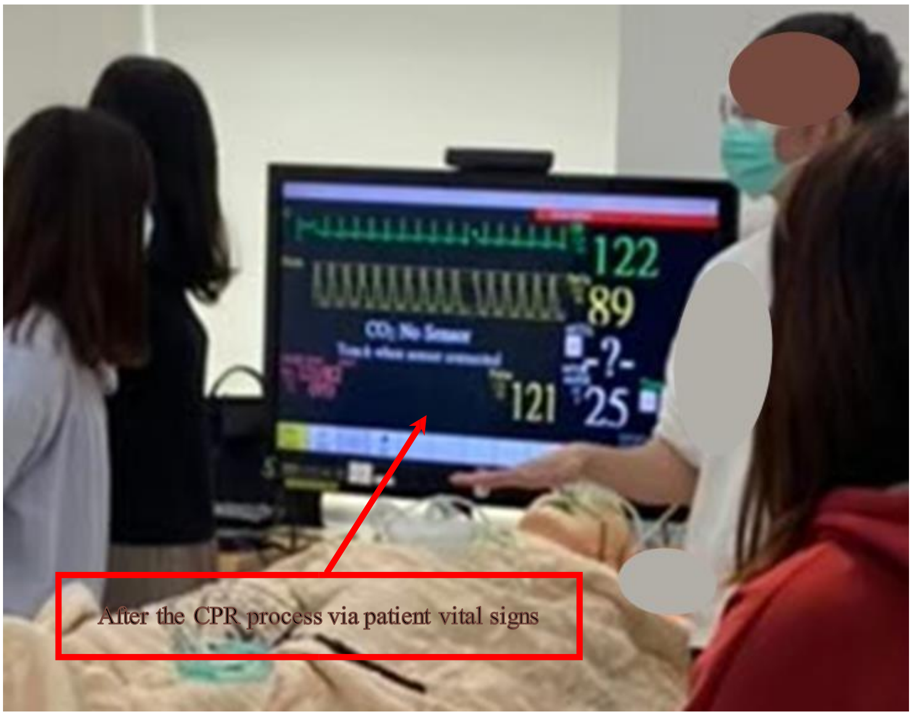

Figure 6. Debriefing for the ACLS situation-based computer-supported personalized and collaborative learning.

2.4 Experimental Results

Analysis of covariance (ANCOVA) was employed by using the pre-test scores of learning achievement as the covariate, while the post-test scores of learning achievement were the dependent variable. After verifying that the assumption of homogeneity of regression was not violated with $F = 3.57$ ($p > 0.05$), the post-test scores of both groups were analysed using the ANCOVA method. As shown in Table 1, it was found that there was a significant difference between both groups ($F = 60.34$, $p < 0.001$). That is, the ACLS situation-based computer-supported personalized and collaborative learning approach had significantly better effects (mean = 89.53; standard deviation [SD] = 5.94) on professional staffs' learning achievement than did the ACLS traditional classroom (mean = 80.87; SD = 5.14). The adjusted means of the experimental group and the control group were 89.72 and 80.68, respectively. This implies that the ACLS situation-based computer-supported personalized and collaborative learning approach could enhance the professional staff's learning achievement more than the ACLS traditional classroom could. In addition, the correlation coefficient ($\eta 2 = 0.514$) was higher than 0.138, implying that the ACLS situation-based computer-supported personalized and collaborative learning approach highly affects professional staff's learning achievement.

Table 1. *learning result of learning achievement*

Variance	Group	*N*	Mean	*SD*	Adjusted mean	*Std. error.*	*F*	*η2*
Learning achievement	Experimental group	30	89.53	5.94	89.72	0.82	60.34^{***}	0.514
	Control group	30	80.87	5.14	80.68	0.82		

$^{***}p < .001$

After verifying that the assumption of homogeneity of regression was not violated with $F = 1.46$ ($p > 0.05$), the post-test scores of both groups were analysed via ANCOVA. As shown in Table 2, it was found that there was no significant difference between both groups ($F = 1.21$, $p < 0.01$). That is, the ACLS situation-based computer-supported personalized and collaborative learning approach did not have significant effects (mean = 4.22; SD = 0.38) on professional staffs' critical thinking in comparison with the ACLS traditional classroom (mean = 4.10; SD = 0.44). Additionally, the correlation coefficient (η2 = 0.21) was lower than 0.138, implying that the ACLS situation-based computer-supported personalized and collaborative learning approach has a lower correlation with professional staff's critical thinking. It can be inferred that the participants were all experienced professionals who originally had stable critical thinking abilities.

Table 2. *learning result of critical thinking*

Variance	Group	*N*	Mean	*SD*	Adjusted mean	*Std. error.*	*F*	*η2*
Critical thinking	Experimental group	30	4.22	0.38	4.22	0.08	1.21	0.021
	Control group	30	4.10	0.44	4.10	0.08		

3. Discussion and Conclusions

To enhance professional staff's in-clinic EKG interpretative ability, this study proposed an ACLS situation-based computer-supported personalized and collaborative learning method that integrated EKG scenes into the clinical learning settings. The multimedia materials mainly introduced the key points of the on-site learning activities conducted by the teacher. The students in the experimental group were able to practice the learning tasks repeatedly by watching the ACLS multimedia (combining videos, photos, and text) in the preclass stage and constructing the prerequisite knowledge, operation skills, and even concrete questions in advance of entering the in-class stage. Thus, in such a learning situation, the students in the experimental group could bring more concrete professional learners' concepts or questions into the in-class stage and interact with the teacher. On the contrary, the students in the control group who did not watch the ACLS multimedia prior to the in-class stage could not gain concrete prior knowledge or operation skills; thus, they had less interaction with the teacher in the in-class stage than the experimental group students did. That is, watching the ACLS multimedia in the pre-class stage could lead the students to understand the ACLS learning situations, and they could focus on the on-site learning situation based on the concrete questions that arose in the pre-class stage. Consequently, the research results show that the professional staff who learned with the ACLS situation-based computer-supported personalized and collaborative learning method gained better learning achievement than those who learned in the ACLS classroom.

This result reveals that professional staff in the experimental group more easily constructed concrete concepts and expertise for ACLS through a continued simulated manner in the pre-class and in-class activities than those who learned in the ACLS traditional classroom. That is, learners in the experimental group were provided with ACLS multimedia and simulation exercises in the pre-class stage. In such a learning situation, not only could the preliminary knowledge and nursing skills for ACLS be constructed, but they could also come up with questions about the specific operations for ACLS in different emergency situations in advance of the in-class activities. Therefore, learners were able to pay more attention to the educator's specific operations for ACLS in the class. Consequently, the proposed approach linking computer-supported personalized and collaborative learning and situated learning could promote learners' higher-order knowledge transition (Bdiwi, de Runz, Faiz, & Ali-Cherif, 2019) and enhance their mastery of ACLS skills before entering the clinic (Bowers et al., 2020). In contrast, those in the control group were not given the multimedia material and simulation exercises in the pre-class stage; thus, they may have brought abstract concepts of ACLS knowledge and skills into the in-class stage. In such a learning situation, it was difficult for the learners to identify their weaknesses and problems when learning ACLS in advance.

The main contribution of this article is that the innovation of the computer-supported personalized and collaborative teaching design course is worth promoting in other forms of education and training of professional staff and all medical staff in the future.

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High-level Cooperative Behavior Model of Online Summit Games

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Abstract: In online summit game system (OSGS), a strategic game was designed to incorporate issues and conflicts between countries that allows players to take on roles in the gaming scenario to engage in a high-level cooperation. This study analyzed the intra-group interaction and high-level cooperation process of summit game. The Interaction Process Analysis (IPA) proposed by Bales is used as an analysis tool to analyze high-level cooperation in online summit games. The results show that, the players are very focused in accomplish tasks trying to give ideas, expressing feelings, giving suggestions and strategies. The setting of issues in strategy games strengthened the conflict between countries in each event, which enabled meaningful discussion, negotiation, and problem solving among students, which illustrate the high-level cooperations among group members.

Keywords: Game-Based Learning, High-level Cooperative Behaviors Analysis, Strategic Game

1. Introduction

1.1 Research goal

Cooperative learning is a way of learning together, in a networked environment, without the constraints of time and space. It allows all participants to exchange information and resources with each other anytime and anywhere (O'Malley & Scanlon, 1990). Students can exchange their ideas and what they have learned, learn from each other, help and correct mistakes, learn to think from different points of view, and learn to cooperate and compete. The continuous interaction between individuals and their environment is essential for the development of cognitive understanding (Ben & KedemFriedrich, 2000). Interaction among team members can create new ideas, and interaction is considered a key reason for creating new ideas and maximizing the value of knowledge (Kang, Rhee, & Kang, 2010). Interpersonal trust can be effective in fostering strong interpersonal relationships among team members and in improving team cohesion. Cooperative learning is an experience of cooperative interaction through mutual help, discussion, and argument. Its most important goal is to provide students with the knowledge, concepts, skills, and understanding to become happy and contributing team members (Slavin, 1995). While general cooperation focuses on friendly behaviors among students, high-level cooperation intertwines self-beneficial and altruistic behaviors for both individual and common goals.

In this study, a strategic game was designed to incorporate issues and conflicts between countries that allows players to take on roles in the gaming scenario to engage in a high-level cooperation. In the game, players not only have their own goals to accomplish that can be contradictory to each other, they also have to reach consensus to solve the conflicts between them through negotiations. The game is presented in the online summit game system (OSGS).

1.2 Research questions

In this study, players have different goals in a strategy game because they have their own division of tasks and need to continuously resolve the conflicts emerging from each event in the game. Players should negotiate effectively with their peers, within and across groups, during the conflicts and eventually achieve a high-level cooperation to achieve the game goal. The research questions for this study is to investigate what the players' high-level cooperation strategies in the online strategic game in the intragroup discussions.

2. Related work: High-level Cooperation

Cooperative learning emphasizes the nature of learning, including personal responsibility, social skills, and teamwork. Group discussions allow team members to share ideas and pass on information, as well as challenge each other, which helps to achieve a higher level of cognitive understanding. Students expand their thinking by discussing with each other in a way that guides them to expand their thinking, allows them to engage in higher level cognitive thinking, and stimulates their multiple learning development. In such an environment, students can collaborate on complex, interesting, and openended tasks that are internalized as part of their independent development (Nijhof & Kommers, 1985).

The knowledge gained from communication and interaction is an important resource for a group's competitive advantage (Alavi & Leidner, 2001), and groups must create new knowledge to maintain an advantage in a rapidly changing environment (Szulanski, 1996). Knowledge is an indispensable resource in interpersonal interactions, and effective interactions make teams more competitive (Argote & Ingram, 2000). Effective interpersonal interactions among team members are highly competitive, but successful interpersonal interactions are difficult to achieve (Argote, Ingram, et al., 2000), and interpersonal trust comes from interpersonal interactions and has a significant impact on interpersonal interactions (Levin & Cross, 2004). Interpersonal interaction is not only a behavior but also a complex interactive process (Nonaka & Takeuchi, 2007). That will involve a large number of social behaviors such as knowledge sharing, interpretation, and integration (Argote & Ingram, 2000), and is an important and effective way to facilitate teams (Yu, et al., 2013). To sum up cooperation are generally friendly, self-interest and altruistic, from the above literatures, the cooperation has three types of cooperation are: (1) active interdependence: work together with team members to complete the task; (2) not alone: when facing complex problems, each person may have his or her own opinion, try to communicate with team members to get a better solution; (3) compromise consensus: Adopt the opinions of both sides and find the points that can work together.

Cooperation focuses on friendly behaviors among players, in which self-interested and altruistic behaviors are intertwined for a common goal. In this study, the strategy game incorporates issues, creates conflicts between countries, and allows players to divide roles. Because of the conflict between countries, players have their own goals to accomplish and a consensus to solve the conflict, they can express their views and opinions through negotiation, and then achieve the goal of solving the task through learning and consensus to achieve high-level cooperation.

This study uses Bales' Interaction Process Analysis (IPA) to classify the content of players' ingroup textual communication in the internal affairs session of the game. Bales' definition of a group has nothing to do with the size of the group, but with the fact that any group member in the group has a clear enough impression or perception of each of the other members so that some reactions can be made to each person at the time or in subsequent questionings, even if it is just recalling the presence of another person (Bales, 1950). IPA focuses on the interpretation and classification of observed behaviors. The observer must infer the intent and meaning of the observable actions. It is an analytical tool for group interaction that is widely used in research, especially for analyzing problem-solving processes. If group members' behavioral patterns are mostly focused on positive reflections, it can be seen that group members are generous in praising group members; and if behavioral patterns are focused on attempting to answer and connoting problem, it can be seen that group interaction is strong, and the above behaviors are more positive for intergroup cooperation. Bales interaction process analysis was originally developed for face-to-face communication, but it has been used in computer mediated research as well (Maloney-Krichmar & Preece, 2005).

3. Online Summit Game Design

Online Summit Game System (OSGS) uses WAMP (Windows-Apache-MySQL-PHP) architecture as a web server framework. WAMP is a group of free software names that run dynamic web sites or servers at the same time. Sublime Text is used as the program editor. The front-end consists of three major elements: HTML for web scaffolding, CSS for web design layout, and JavaScript for presenting web dynamics, which is the programming and language for the game interface style and function design, while the back-end consists of PHP and MySQL for storing and reading game data files through multiple data tables.

The game mechanism in this study is based on the maker game for the Great Voyage <Fragrance Channel> developed by Shih, Huang, Lin, and Tseng (2017), which uses the 17th century spice trade in the Great Voyage time as the game scenario. Two gaming objectives include the total assets of each country increases, and all crises presented in the game are resolved with consensus. The rise of the national assets requires spice trading to earn income; and the conflict resolution requires intragroup action strategies and intergroup negotiations.

Account passwords are created for every role of each country in OSGS. Players role-play as captain, diplomat, trader, or internal affairs officer in the five countries, namely England, France, Portugal, Spain, and Netherland. The roles in the game are randomly assigned to the players to draw randomly so they do not know who is beyond the system in the game. Before the game, the teacher introduces the background of the game and guides players through the context.

This game is divided into several phases (Figure 1). Phase one is the opening scene with territorial competition through auctions, "Preemption". Since the initial wealth and manpower of each country are different, each country has to occupy colonies in phase one to plant spices to earn income. Then the game enters phase two in which three historical crises are presented and needed to be solved all at the same time. The three crises were designed to inter-related to each other whereas the resolution of one crisis might affect the decision of the other two. The first crisis is "Scurvy", wherein a mysterious sailor's disease appear and cure needed to be found to prevent sailors' death. The second crisis is "The Treaty of Tordesillas" which divided the newly discovered land outside of Europe between Spainish and Portuguese Empires. In the history, the lands to the east would belong to Portugal and the lands to the west to Castile which had caused colonies of the European countries whereas other European countries might choose to ignore the treaty. The third crisis is "The Hundredyear Hatred" in which a military conflict fought between France and England occur. However, the long-standing confrontation between England and France was thought to be committed by France but turned out to involve Netherlands' conspiracy in the game (designed to increase gamified involvement of all countries). In all crises, there were secret information to some of the countries that increase the negotiation tension between them.

In phase two, players have to find treatments to the crises in three rounds. Each round goes through four stages. First stage is internal affairs. Each country has to make the strategic plans for the crisis resolution, prepare for the declarations, and make the inventory. Second stage is diplomacy. This time is for international negotiations to make new rules and reach consensus on treating the crisis. The challenge is for each country is to accomplish their own goals but at the same time to comply for common benefits. The third stage is declaration. The captain will make declarations on behalf of each country annoucing their final decisions to crisis treatments and posting their stands to the international conflicts. The fourth stage is settlement. The pope will evaluate the international conditions based on declarations and make settlement to crisis resolution outcomes.

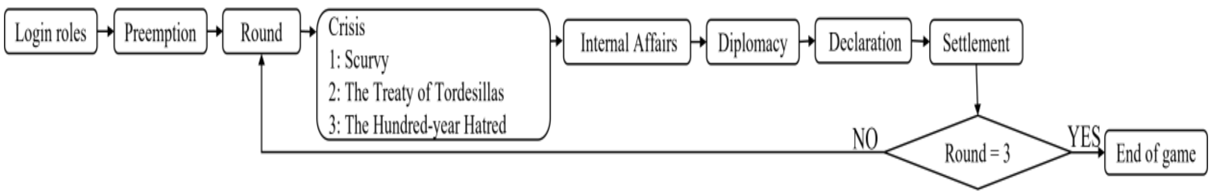

Figure 1. Game flow

Placing different issues in the game allows players to present their individual views and positions to the issues which is a good opportunity for players to learn teamwork, communication, coordination, and independent thinking, as well as to establish good value system. In this study, the background of the 17th century maritime era was used as the game scenario that comprises the knowledge of geography, history, and various disciplines including health issues. With the game mechanism, the players were guided to take the initiatives, cooperate as a team, and solve the situational problems in the game, which is very important for reaching the high-level cooperation among the group.

4. Research design

4.1 Research Framework

Fifteen graduate players majoring in educational technology and network information in Taiwan was invited to participate in this study. There were 7 males and 8 females who were randomly divided into groups of three to form a country.

This study was to analyze the high-level cooperation in the summit game from the textual interactions documented in OSGS. The overall course time was two and half hours. The research process of this study is as Figure 2. Before the game starts, the rules of the game and the operation of the system are explained. The gaming processes are documented in OSGS. After the game, students are guided to reflect on the game and fill out the game system feedback questionnaire.

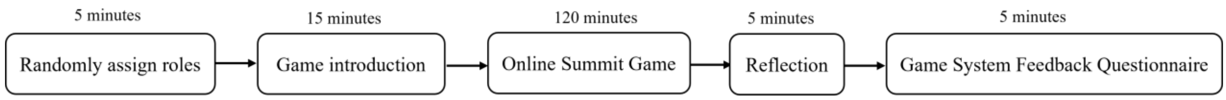

Figure 2. Research process

4.2 Research Tools

This study analyzes the records of players' high-level cooperation strategies in the online strategic game in the intragroup discussions. All dialogues are coded sentence by sentence. Interaction Process Analysis (IPA) proposed by Bales (1950) is chosen to be the coding scheme. Bales interaction analysis divide categorize interactions into three major domains (positive socioemotional domain, negative socioemotional domain, and neutral task domain) containing twelve categories. The questions task domains is a set of questions describing the activity. The attempted answers task domain is a set of activities trying to answer. The positive socioemotional domain contains several different positive responses, and negative socioemotional domain contains a set of negative responses opposite to positive socioemotional domain. The middle region of the system. The attempted answers task domain and the questions task domains are considered as task problem areas, while positive socioemotional domain and negative socioemotional domain are considered as social-emotional problem areas. The idealized interaction process is an interplay between the task and socioemotional behavior domains. When the focus is on the task, the social and emotional relationships of group members may become more tense, and conversely task completion is less effective when the group's activities are focused on social-emotional activities. (Table 1).

Table 1. *Bales' Interaction Process Analysis*

Domains	Categories	In Game example sentences
Socio-motional Area: Positive	Shows solidarity, reward	Go Captain, you are great!
	Shows tension releases, jokes	It's okay, I don't feel any loss.
	Shows acceptance, Agrees	Agree Have enough money.
Task Area: Attempted Answers	Gives suggestions: Cue others to initiate	Find out which country has the antidote.
	Gives opinions: Expression of feelings Gives information	I leave it to you. Don't let me down. Netherland ants to trade with Spain
Task Area: Questions	Asks for information	What is the conclusion
	Asks for opinions: Expression of feelings	Want to be cheated by him?
	Asks for suggestions: Cue others to initiate	Which port to grab
Socio-motional Area: Negative	Shows rejection, Disagree	Why is it not solved?
	Shows tension, Asks for help	
	Shows unfriendly, defends	

5. Results: Intragroup - High Level Interactive Behavior Analysis

Players' high-level cooperation behaviors are categorized and analyzed with IPA (Table 2).

Table 2. *High-level cooperation behavior categories*

Domains	Categories	England	France	Portugal	Spain	Netherland
Sociomotional Area: Positive	Shows solidarity, reward	2	9	1	1	11
	Shows tension releases, jokes	2	10	4	4	2
	Shows acceptance, Agrees	20	12	20	9	19
Task Area: Attempted Answers	Gives suggestions: Cue others to initiate	8	7	11	6	10
	Gives opinions: Expression of feelings	15	29	30	46	33
	Gives information	21	36	54	59	51
Task Area: Questions	Asks for information	18	26	17	15	18
	Asks for opinions: Expression of feelings	15	11	10	6	13
	Asks for suggestions: Cue others to initiate	8	21	11	12	6
Sociomotional Area: Negative	Shows rejection, Disagree	2	0	0	0	0
	Shows tension, Asks for help	0	0	0	0	0
	Shows unfriendly, defends	0	0	0	0	0
Total		111	161	158	158	163

The total number of sentences in the dialogues is the lowest compared to other countries since England is the only country that does not need to solve crisis one "Scurvy". In the game, England has lemon on their ship since the beginning, so they do not have to negotiate with other countries to resolve the crisis. Other than that, England's interaction focused on attempting to answer and connoting questions. Conversations between group members include queries to the captain if tradings should be planned.

Similarly, France has large ratios of dialogues on attempted answer and questions. Behaviors in the positive social-motional area occurred 31 times in France, including (giving praise, making jokes, laughing, and agreeing). It was observed that the group members did not hesitate to praise others and gave positive feedback showing their solidarity. The dialogue was mainly in the form of questions and answers, ranging from asking about possible actions to expressions of personal opinions and feelings. The captain quested the members their thoughts and make the plans together which leads to a smoother game.

Portuguese interactions were mostly in socio-motional area and attempted answers. Total of 95 sentences were in the attempted answer including (giving suggestions, ideas, and information). They wanted to go to England to sell information and obtain the antidote by selling spices and discussed about tax exemptions with France. The Portuguese group as a whole would actively give their own ideas and opinions and would express their views on what they saw and how they might solve the crisis. Their group proceeds the game well.

Spanish group also has high ratio of attempted answers and questions. Total of 111 sentences were in the attempted answer category including (giving suggestions, ideas, and information). Group members offered several negotiation, lying and allying strategies with other countries. The whole group actively give their own ideas and opinions which lead to clear decisions and reach consensus for the country development.

Netherlands group also has high ratio of attempted answers and the questions. Total of 94 sentences were attempted answer behaviors including (giving suggestions, ideas, and information). Since in one of the crisis they are the hidden enemy, the whole group followed the captains' order to pretend to be innocent and frame the French. The whole group actively give their own ideas and opinions and express their observations and possible resolutions to the crisis, so they progress the game well. In addition, the Netherlands has relatively weak initial funding, so the team are actively discussing strategies to increase assets and reach game goals.

6. Conclusion

This study analyzed the high-level cooperation of intragroup interactions with OSGS. The results show the players are very focused in accomplish tasks trying to give ideas, expressing feelings, giving suggestions and strategies. The contribution of this study is that it can guide players to achieve high-level cooperation through summit games. High-level cooperation is different from general cooperation in which players have their own roles and tasks to accomplish, at the same time to reach consensus for conflict resolutions. In this study, the setting of issues in strategy games strengthened the conflict between countries in each event, which enabled meaningful discussion, negotiation, and problem solving among students, which illustrate the high-level cooperation among group members. The design of effective summit game require three necessary elements: (1) the issues that involve all parties, and each has different positions; (2) the conflict can be solve with cooperation and competitions through negotiations; (3) tensions between individual goals and common goals should be presented so high level cooperation would happen In addition, sufficient time should be given for intragroup and intergroup negotiations so that the understanding to the issues, perspective-taking, expression of ideas, mutual trust, and mutual assistances can be enhanced to achieve to a higher level.

Acknowledgements

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Issue-based Guided Inquiry Model with Real Socioscientific Open Data <City Auncel>

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Abstract: Scientific literacy is one of the key learning for modern students to be cultivated. Therefore, the main purpose of this study is to propose a issue-based guided inquiry model wherein students use real open data to solve socioscientific issues. Through hypothesis, students actively conduct content investigation, data collection and interpretation, and ultimately result generalization to build their own resolutions to treat socioscientific issues. Then, students learn from each other about the content interpretations and at the same time hear and compare different results done by the other groups. The results show the online guided inquiry model can increase students' motivation to learn and open-ended questions with appropriate orientation will encourage students to delve deeper.

Keywords: Inquiry-Based Learning, Issue-Based Learning, Socioscientific Issues

1. Introduction

Inquiry is commonly seen as a mode of learning scientific knowledge to understand a phenomenon that arises in the natural and physical world, as a mode of learning experience, as a method of acquiring knowledge and process skills (NRC, 2000), and as a way to satisfy one's curiosity about everything, thereby to satisfy the individual's curiosity about everything, the process of exploring knowledge and summarizing and internalizing it is autonomous (Haury, 1993). Yet, there is still much room to improve the instructional design in terms of its universality and variety to be applied in other disciplines. In the online learning environment, it is fast and convenient to inquire information by exploring the web on the search engines. However, with guided inquiry, students would be limited to confined chosen data and fixed answers while without guided instruction, students might be lost in the open inquiry.

Therefore, the main purpose of this study is to propose a issue-based guided inquiry model wherein students use real open data to solve socioscientific issues. In the model, students have guided steps to approach the issues, but free to explore relevant information in real open data and come up with proposed resolutions from the perspective they assigned to role-play. It encourages active and reflective learning as well as fosters scientific literacy by allowing students to ask questions regarding the social issue, collect data they believe to be necessary, analyze and interpret the data, summarize the results to present their individual perspective with scaffold learning sheets, and hear different perspectives in the post-activity showcases and discussions.

In this study, students are provided with a variety of real open data containing text, values, images, maps, and interactive sites. Students are given inquiry guidance to come up with solutions. Thus, the research question is how the students proceed to the issue-based guided inquiry with real socioscientific open data in the <City Auncel> activity.

2. Related work

2.1 Inquiry-based learning

Inquiry-based learning is seen as a way of transferring the process of scientists' inquiry into knowledge to students' learning (NRC, 1996). Scientists approach problem solving by going through a continuous process of inquiry, through problem discovery and problem solving, in order to facilitate their own approach to explore the material and conceptual world; and by using a structural modeling approach to learning, continuously revising and refining their own unique models of inquiry in the process of inquiry (Buck, 2008). It serves as a link between the self's conceptualization of the world of experience and scientific knowledge (Duit, Roth, Komorek, & Wilbers, 2001) by using an architectural model of learning to continually modify and refine one's own unique inquiry model during the inquiry process (Buckley & Boulter, 2000). This learning model can be seen as a process of constructing knowledge, asking and refining questions, articulating one's ideas and discoveries, and explaining one's findings through direct experience in real-world settings (Song & Kong, 2014). This approach is considered to be a problem-solving approach that involves the application of multiple problem-solving skills (Pedaste & Sarapuu, 2006). Teachers should play a guiding role in the inquiry-based learning process by helping learners to brainstorm, ask exploratory questions, develop plans and conduct investigations, collect data, gather information, and apply the information to analyze and interpret the data (Hakkarainen, 2003). Looi (1998) also states that inquiry-based learning is a learning strategy and a learning strategy and that the primary focus should be on how students actively explore knowledge.

2.2 Issue-based learning

Problems arise in the social sciences are essentially philosophical and empirical in nature. Socioscientific issues include debates between different social, economic, and environmental viewpoints, but because these viewpoints are rarely fully aligned, the resulting debates are not suitable for a purely scientific solution. Thus, the problems lie at the intersection of different human interests, values, and motivations. So there is a need for adequate educational exploration treating these issues, the need to train students to recognize the constructive nature of socioscientific issue inquiry in particular the limitations of a purely applied scientific perspective, and conversely, the need for curriculum and pedagogical approaches that are fundamentally constructivism, a model of education in which social science issues are generally considered to be shaped by human interests and social and environmental contexts (Robottom, 2012).

3. Socioscientific Issues and Online System Design

"The endangered Shihu (Leopard Cat)" is used as the theme of the activity of <City Auncel> as the examplary Taiwan socioscientific issue. Factual information is presented based on the Miaoli area in Taiwan where the survival and activity rate of Shihu is currently the highest. Students explore the real open data assigned to use in the inquiry system with guided steps. Real open data and resource sites selected for <City Auncel> include four domains (Figure 1): 1. Water Resources; 2. Land Information; 3. Animal Conservation; 4. Vegetation Distribution. Web forms are used and plugged in to the inquiry system providing information and recording the activity process of learners' explorations. Through the inquiry process, learners quickly understand the in-depth content of the topic, and carry out a complete search for information, and document findings, express their positions regarding to the issues in the system.

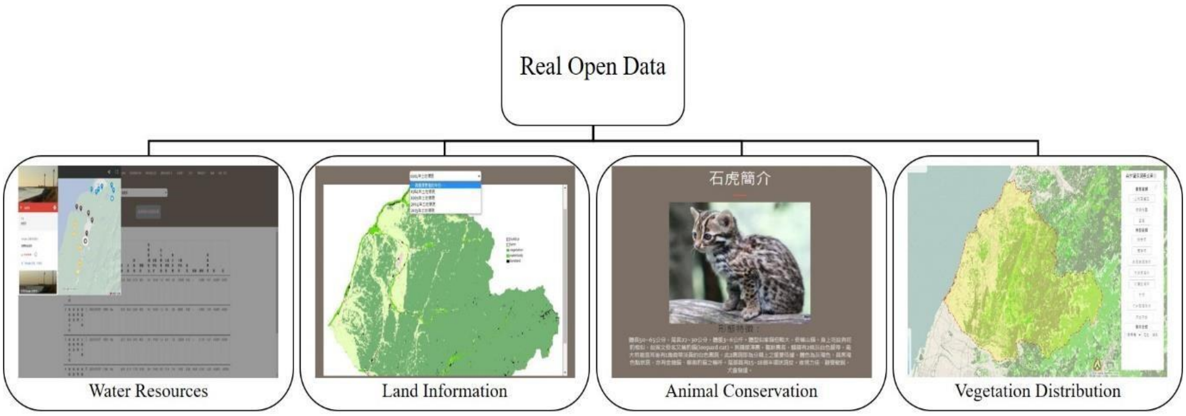

Figure 1 Real open data domains for <City Auncel>

The endangered Shihu issue comprises six key factors: (1) the excessive development of the land leads to the disappearance of Shihu habitat; (2) the development and construction of the road fragmented Shihu habitat; (3) road kills; (4) traps for hunting poultry and livestock that accidentally caught Shihu; (5) pesticides and poisonous bait, accidentally poisoned Shihu, or reduce Shihu's food supply; (6) human beings hunt Shihu to eat the meat. The inquiry is open inquiry without disclosing the six factors to the students but to guide them to explore the reasons that affect the survival of Shihu. With the real open data of the above four domains, students gain insight into the composition of causes, describe phenomena, and make action plans.

The inquiry starts from the introduction to Shihu's endangerment (Figure 2). After the introduction, students were asked to form groups of three with respective roles. Through diverse real open data, students complete their individual task in the role. Once the individuals submit the investigation report with action plans, they have discussions within groups to gain insights from perspectives of different roles. Thus, students learn from each other about the content interpretations and at the same time hear and compare different results done by the other groups.

Figure 2 Activity Flow

4. Research design

4.1 Research Framework

The online socioscientific inquiry activity was conducted in an in-service graduate course at a university in Taiwan. Twenty-four students, 14 males and 10 females, are with information technology and education backgrounds. The age of the participants were between 24 and 50 years old. They were randomly divided into groups of three with total of 8 groups.

The research process of this study is as *Figure 3*. Before the start of the inquiry activity, the introduction of the topic and the system operation instructions were carried out. After the inquiry, the students do reflection and feedbacks.

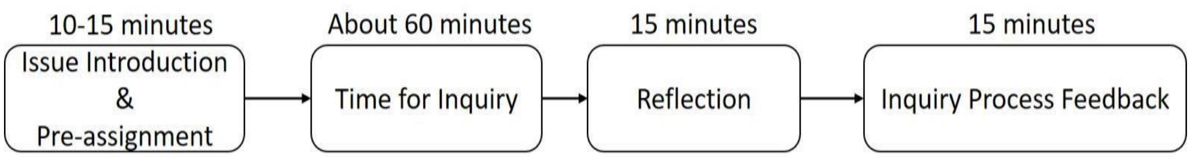

Figure 3 Research Process

4.2 Research Tools

Table 1 shows the guided inquiry 5-step process and content of <City Auncel>. The first step is to explore the context with an open-ended question. In <City Auncel>, we asked "Where do you expect to conserve or develop?". The second to forth steps guide the students to explore the real open data within the given domains points to the factors of targeted issue. In <City Auncel>, each of the guided questions aims to address certain crisis factor for endangered Shihu. Students conduct in-depth investigations of the plantations of the chosen area, the altitude of land, road and commercial development, etc. The last step is hrough this topic, students can have a further understanding of the existential crisis of Shihu in the process of inquiry learning.

Table 1. *Guided Inquiry Model*

Step	Guidance	Question Type	<City Auncel> example
Step 1	Explore the issue context	open-ended	Where do you expect to conserve or develop? (Choose an area with predicted reasons.)
Step 2	Explore real open data with assigned domain	guided to explore	How is the water quality in the chosen area?
Step 3		guided to explore	What are the forest types at the chosen area?
Step 4		guided to explore	What is altitude of the chosen area, and are there road development?
Step 5	Explore real open data beyond assignment	close-ended	Is the chosen area on the Shihu's corridor?

5. Results

5.1 Domains of Inquiry

For step 1, the open-ended question, students make their action plans in their roles. Their plans were analyzed and categorized in the unit of words and sentences in terms of the content items that students mentioned in their reports. Total frequencies of analysis categories are shown in Table 2.

The total frequencies of students inquiry items out of 8 groups are 54, among which the domain of Land Information is mostly mentioned. From the interviews, it is known that the students have overviewed step 2 and 3 about investigations to Water Resources and Vegetation Resources, so they put more informatioin related to land and Shihu in step 1. Meanwhile, students also mentioned information beyond the assigned 4 domains including culture, population, and role perspectives.

Table 2 *Total frequencies of inquiry items in data categories*

Data Domains	Total Frequencies of Inquiry Content Items
Water Resources	8
Land Information	21
Animal Conservation	13
Vegetation Distribution	2
Culture	1
Population	2
Role Perspective	7
Total Items	**54**

5.2 Inquiry beyond Domains

Figure 4 shows the domains and categories of the data content investigated by students.

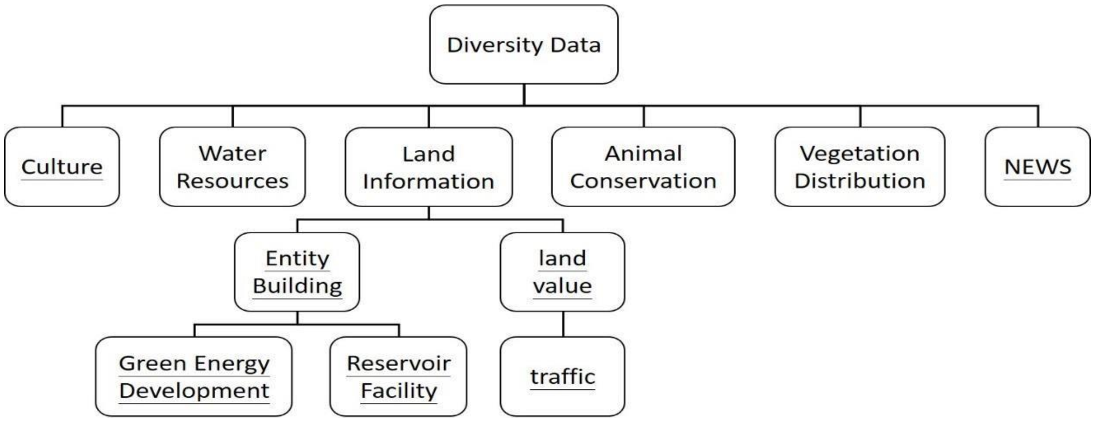

Figure 4 Inquiry Model

It is found that students explore beyond the original four domains of data on land information, water resources, animal conservation and vegetation, and have more explorations into entity building, land value, green energy development, reservoir facility, and traffics. It is evident that they have interest in the inquiry model to explore more for resolving the issues. Nevertheless, in this study, students focus more in the land information domain since it is the only open-ended question. Questions leading to other domains are guided questions that limited students' motivation and curiosities to conduct free explorations in those domains. It is to conclude that open-ended questions with appropriate directions would encourage students to do in-depth inquiries.

6. Conclusion

In this study, we propose an issue-based guided inquiry model that allows learners to explore a variety of real open data. Through hypothesis, students actively conduct content investigation, data collection and interpretation, and ultimately result generalization to build their own resolutions to treat socioscientific issues. The online learning system allows learners to explore the content they wish to know through other means other than the content designed by the researcher, which in fact shows the learners' commitment to the exploration of the topic. It is evident that the online guided inquiry model can increase students' motivation to learn.

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Proposing a Collaborative Multi-agents System for English Learning Support

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Abstract: Collaborative learning has been as advocated as a promising approach for stimulating higher achievement among learners. However, its benefits can only be maximized in active and cooperative teams. In this paper, we propose a collaborative English learning environment where the learner teams up with two computer-driven agents. In the proposed system, depending on the learning stage, learners and agents fulfil different roles, thereby offering learners the opportunity to not only observe but also teach and get taught by agents in a collaborative fashion. We conducted a preliminary evaluation experiment of the proposed system, and obtained results tend to confirm the meaningfulness of the proposed approach for enhancing learners' engagement towards learning.

Keywords: Learning by teaching, Teachable agent, Collaborative learning, English learning

1. Introduction

Collaborative learning is widely recognized as an effective educational approach. Its benefits have been investigated from various perspectives (Laal et al., 2012), and its learning effects are fostered through cooperative interactions among learners. However, some difficulties, such as learners' recruitment and cooperative relationships building, often arise and prevent achieving effective collaborative learning (Le, 2018). Therefore, there have been several efforts to propose computer-mediated collaborative learning involving computer driven peer agents and learners.

For instance, Teachable Agents (TA) are a typical example of pedagogical agents that aim at interacting in a collaborative fashion with learners. TA are designed to provide learning by teaching opportunities to learners (Blair et al., 2007; Brophy, 1999). Learner's act as a tutor and provide knowledge to the TA; the TA, on the other hand, demonstrates the task based on the knowledge given by the learner. It has been shown that learners are influenced by the protégé effect in their interactions with the TA, given that the protégé effect has the effect of increasing learners' motivation (Chase et al., 2009).

Nevertheless, although TA can be effective in helping learners demonstrate and deepen their understanding of previously learned contents, such agents are not necessarily intended to provide new knowledge to learners, as a tutor agent would do for example. Therefore, our idea is to propose a collaborative learning environment where the learner teams up with two computer-driven agents. One agent is more knowledgeable than the learner and provides new knowledge to the learner. In the other hand, the second agent has less knowledge than the learner and is designed to behave like a teachable agent. In other terms, the proposed learning environment embed both a tutor agent and a teachable agent, thereby providing learners opportunity to both acquire new knowledge and demonstrate such knowledge in a collaborative fashion.

In addition, to the extent of fueling within team interactions, we introduce a new learning method which allow the learner and the agents to play different roles while carrying out picture description task in English. The method provides a step-by-step learning process for the learner by rotating the roles of the learner and the agents according to the learner's progress. The act of rotating roles is consistent with effective collaborative learning group behavior (Dillenbourg, 1999). This also offers the learner the possibility to observe the agents from different perspectives.

2. Proposed System

2.1 Collaborative Learning Environment with Multiple Agents

In the proposed collaborative learning environment, we refer to the tutor agent (i.e., more knowledgeable) agent as the Superior Agent. The Superior Agent has more knowledge than the learner and is responsible for providing tutoring content to the learner. The Superior Agent selects and presents the learner with new learning contents and provide feedback as necessary. The other agent is called the Inferior Agent. This agent has less knowledge than the learner and is responsible to provide learner the opportunity to teach or demonstrate acquired knowledge.

In this learning environment, the learner learns new knowledge by interacting with a Superior Agent. The learner can then teach the learned knowledge to the Inferior Agent. The inferior agent grows according to the knowledge it learns from the learner. Therefore, the learner is at the heart of the learning interaction and has the role of transferring the knowledge held by the superior agent to the inferior agent. The goal of this learning environment is for the learner and inferior agent to acquire more knowledge and take on more advanced tasks.

2.2 Picture Description Task based English Grammar Learning

Picture description task is an effective way to learn a foreign language (Albino, 2017). Learners are presented with a picture and asked to describe it. Learners describe the picture using as much vocabulary and grammar rules as they know.

Our proposed system provides game-style learning based on a scene description task involving three roles: Game Master, Describer and Illustrator. As mentioned earlier, the system features two agents and a learner, and they progressively switch roles as the interaction evolves. At the beginning of the game, the screen shown in Figure 1 is displayed. The first player, called the Game Master (GM) is responsible for crafting the scene to be described. To such extent, the GM is prompted to click on any of the red buttons appearing on the screen. Upon clicking, a list of objects is presented. Then, the GM selects one of the objects and the corresponding object is displayed at the position of the selected red button. The GM may add more objects to the scene according to the instructions.

When the GM's task is completed, the interface shown in Figure 2 is displayed. This interface also shows the scene previously created by the GM on the top-hand side of the window. Here, the second player, the Describer, is prompted to observe the displayed scene and describes its contents. At the bottom of the interface, buttons with 6 types of parts of speech are placed. By pressing each of these buttons, the Describer is presented with a list of words belonging to each category. Upon selection of a given word, it appears on the text box placed on the center of the screen.

After the Describer's task is completed, the interface shown in Figure 3 is displayed. The text written by the Describer is displayed at the bottom of the screen. Then, the third player, the Illustrator, reads the text and tries to reproduce the scene described by the Describer. Note that here, the operation of the interface is similar to Figure 1.

When the Illustrator's task is completed, the interface shown in Figure 4 is presented to the learner. The picture created by the GM is displayed in the upper left corner of this screen. In the upper right corner, a picture created by the Illustrator is displayed. The text written by the Describer appears at the bottom of the two pictures. This review interface is used by the GM to provide feedbacks to the Describer, and by the Describer to evaluate the Illustrator.

The proposed learning system is considered to have learning effects from three perspectives. The first perspective is the learning effect of the role task. The Describer is given the task of faithfully describing the picture created by the GM in English. Therefore, by taking on the role of Describer, learners improve their ability to describe what they see through writing. The Illustrator is given the task of reading the English text created by the Describer and reproducing it in picture. Therefore, by taking on the role of the Illustrator, learners improve their ability to read and understand the text correctly. The GM is given the task of generating meaningful scenes according to the instructions. Therefore, by taking on the GM role, learners are given the opportunity to think about the picture description task in a structured manner.

The second perspective is the learning effect of collaborative learning. In the proposed system, the goal is for the Illustrator to reproduce the scene originally created by the GM. Hence, success of this task is bound to both the Describer's writing skills and the Illustrator's reading skills. Learners need to provide appropriate feedbacks to other players as they play the roles of GM and Describer. The GM, for instance should adjust the difficulty of the scene to help the Describer or Illustrator learn advanced

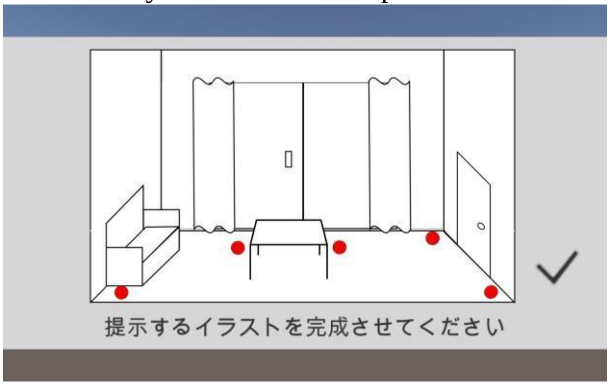

Figure 1. Game Master's Interface

Figure 2. Describer's Interface

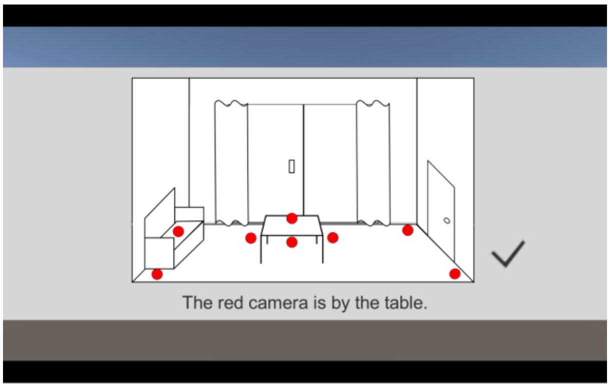

Figure 3. Illustrator's Interface

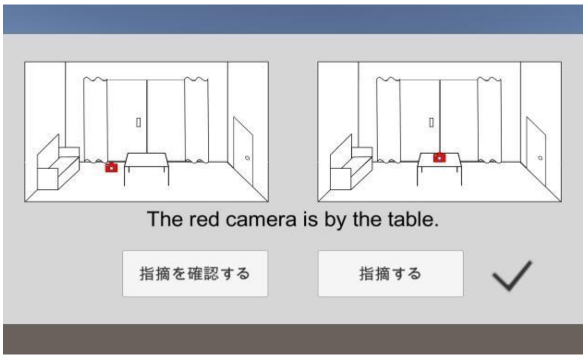

Figure 4. Review Screen

expressions. The GM also needs to keep track of the learning progress of other players in order to provide them with description tasks of appropriate difficulty. Therefore, the learner needs to deeply observe the results of tasks performed by other players.

The third perspective is cognitive apprenticeship-based learning and teaching. Learner and agents can learn and teach based on cognitive apprenticeship by rotating their roles. Cognitive apprenticeship is a method that allows traditional apprenticeship to be applied to education (Collins et al., 1991). The core processes of this model are Modeling, Coaching, and Scaffolding. Modeling is when the expert performs a task and allows the student to observe how it is done. Coaching is the intervention by the expert to help the student execute the same performance as the expert. Scaffolding is the expert helping the student perform the task.

Learner and agents switch roles in three phases. In the first phase, the learner plays the role of Illustrator, the Inferior Agent is the GM, and the Superior Agent is the Describer. In the second phase, the learner plays the role of Describer, the Superior Agent plays the GM, and the Inferior Agent plays the Illustrator. In the third phase, the learner plays GM, the inferior agent plays Describer, and the superior agent plays Illustrator. Each phase is completed when the Illustrator is able to reproduce the GM's illustration.

These three phases are intended to reproduce an expert-student relationship from the standpoint of Cognitive Apprenticeship, as far as the Superior Agent-Learner and the Learner-Inferior Agent interactions are concerned. First of all, in the first phase (i.e., learner: Illustrator, Inferior Agent: GM, and Superior Agent: Describer.), the system controls the Inferior Agent to present the Superior Agent with a picture description task that requires knowledge about the learner's unmastered domain. Here, the Superior Agent performs Modeling for the learner by providing correct responses to the task. Next, In the first half of the second phase (i.e., learner: Describer, Superior Agent: GM, and Inferior Agent: Illustrator.), the Superior Agent presents the learner with a picture description task that requires knowledge of the same domain as the task in the first phase. At this time, the Superior Agent provides Coaching through feedback and Scaffolding through hints. By the end of the second phase, the learner is expected to have mastered the domain knowledge if he/she is able to provide a correct answer. Learner's correct answers at this point of the interaction serve as Modeling to the Inferior Agent. Finally, in the third phase (learner: GM, Inferior Agent: Describer, and Superior Agent: Illustrator), the learner coaches and scaffolds the inferior agent, thereby fostering the mastering of learned contents by the Inferior Agent.

3. Pilot Study

3.1 Outlines

To the extent of investigating the meaningfulness of the proposed system, we carried out a preliminary pilot evaluation of the system in which subjects experienced the process of learning English prepositions (i.e., in, on, under, beneath, etc) using a prototype system. The prototype system was developed using Unity, a game development engine. Participants were 10 male and female students attending a Japanese university. Subjects experienced various situations that could possibly occur when interacting with agents in the system, through three phases. In Phase 1 and Phase 2, subjects were instructed to purposefully provide an incorrect response and later to provide the correct response after being pointed out by the Superior Agent. In Phase 2 and Phase 3, the inferior agent was set to give an incorrect response and the subject was instructed to point it out.

Note that the prototype system used in this experiment does not embed the function to adjust the difficulty of the task according to the subject's knowledge. Therefore, in order to minimize differences in subjects' knowledge, we explained to them that they should operate the system under the assumption that they were currently studying prepositions.

Table 1 shows the questionnaire items used in the evaluation experiment. The questionnaire items were rated on a 5-point Likert scale going from agree / slightly agree / neither / slightly disagree to disagree. In addition, a free-writing section was also included so as to collect subjects' opinions on the system.

Table 1. *Questionnaire Items*

Number	Question
Q1	Was the system easy to use?
Q2	Was the task difficulty level appropriate?
Q3	Was the task you worked on enjoyable?
Q4	Would you like to use this system in the future for learning English grammar?

3.2 Results and Discussions

From the results of the questionnaire, we discuss whether the use of the proposed system for learning English is meaningful for learners. The questionnaire results are shown in Figures 5-8.

Q1 asks about the usability of the system. We found that all subjects answered "agree" or "slightly agree". In this experiment, only the operating procedure was explained orally, but all subjects were able to perform the task. Therefore, our system has an intuitive UI design that can be operated by many people. In the free-writing section, some subjects responded that they would like a function to return to the previous screen when they made a mistake. This suggests that the reason why 90% of the subjects answered "slightly agree" instead of "agree" was because there were some minor aspects of the system interface that could be improved.

Q2 and Q3 ask whether the tasks performed in the proposed learning system provide a good learning experience for the learners. We found that 80% of subjects responded "agree" or "slightly agree" to Q2, and all subjects responded "agree" or "slightly agree" to Q3. This result suggests that the proposed system gives learners a satisfactory learning experience. In the free-writing section, one subject responded, *"I enjoyed visual learning of English in the game"*. This suggests that the proposed system can provide learners with a more sensory and enjoyable learning experience than conventional learning methods using textbooks.

Q4 asks about their motivation for using the proposal system. We found that 80% of the subjects responded "agree" or "slightly agree". This result indicates that many subjects are motivated to use the system. This suggests that learners can learn more actively by using the proposed system.
In the free-writing section, we received comments such as *"I felt that being aware of what I was doing now would enhance my learning"*. On the other hand, one subject commented, *"I found it difficult to know my role and what I was supposed to do,"* and *"I felt the system should indicate who wrote the pictures and text"*. Therefore, it was suggested that posting information on the UI, such as the user's role and the actions currently required, could enhance learning effectiveness by increasing the learner's awareness of their role during the scene description task.

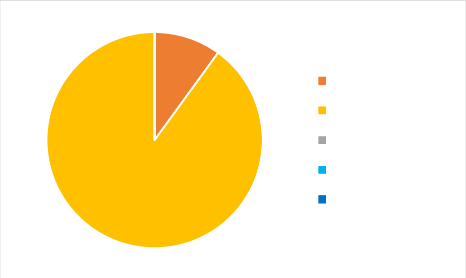

Figure 5. Q1 Questionnaire Results

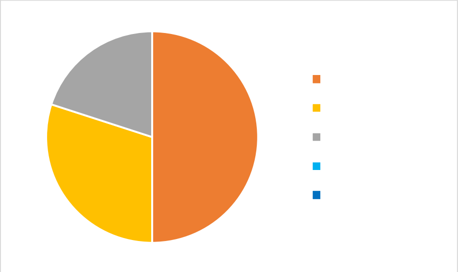

Figure 6. Q2 Questionnaire Results

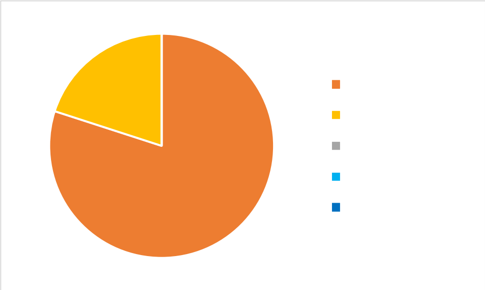

Figure 7. Q3 Questionnaire Results

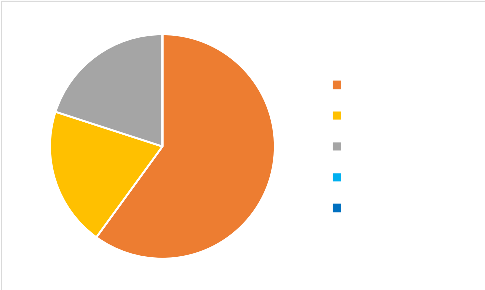

Figure 8. Q4 Questionnaire Results

4. Conclusion

Collaborative learning has been as advocated as a promising approach for stimulating higher achievement among learners. However, its benefits can only be achieved in active and cooperative teams. In this study, we proposed a collaborative learning support system in which the learner and two computer driven agents with different abilities, perform picture description tasks while fulfilling different roles. Moreover, roles are progressively rotated so that the learner cannot only observe, but also learn from and teach the agents depending on their role. We then, carried out an experimental evaluation to evaluate the system's usability and meaningfulness. We found that the proposed system provides an intuitive and enjoyable learning experience to learners. We also found that there is still room for improvements as far as the UI and interaction design is concerned. The relatively small number of subjects during the pilot evaluation is also a limitation that we acknowledge.

Future works will be dedicated to tackle the above issues and also devise a method for dynamically generating scene description tasks based on learner's knowledge. We will also work on improving the feedbacks presented to learners throughout the interactions. In addition, a formal study with pre-testing and post-testing should be conducted using the completed system.

Acknowledgements

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Reshaping Teachers' Professional Identity Through Technology-based Integrated Pedagogy

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Abstract: Innovative teaching strategies developed by university-level teachers in teaching English as a Foreign Language (EFL) shapes both their professional identity and pedagogical practices. A range of strategies in using innovative technology-integrated pedagogy are scrutinized for how they meet contemporary challenges. Based on qualitative research through narrative inquiry, the study explores the practices, perceptions and observations of seven university faculty sharing their stories of classroom experiences in reshaping their pedagogical practices in integrating technology in the Nepalese context. A questionnaire, reflective sharing, and interview were used as tools to elicit their practical experiences in reshaping their professional identity and pedagogical practices. Findings show that teachers explored the available resources using technology despite technical challenges, nominal or no institutional support and managing their wellbeing. Technical knowledge was a basic requirement that the teacher needs to as a foundation to use several technological applications. This knowledge develops confidence and helps map the content to be used in the classroom for successful integration of technology. It also boosts motivation in the students and eases learning of the textual context. The study concludes that a gradual shift in using technology is helpful for a teacher to address the demand of students as one of the options and keep oneself in a comfort zone. It is recommended that establishing an Information Communication Technology Support Centre for the teachers and students can uplift their technical skills, motivation and positive practices in classroom delivery, assessment, and innovative practices.

Keywords: identity, technological acceptance, instruction, integration, challenges

1. Introduction

In recent years, the use of digital technology has rapidly increased in classroom practices and made teachers more responsive in reshaping their professionalism. The advancement of computer technologies and the development of the internet have a significant influence on the educational environment as process, products, and services for sustainable development (Abubakre & Mkansi, 2022). The use of the resources using the internet as a means has made educators rethink their ways of instruction in their classrooms (Hammond, 2021) and even in managing administrations. Teachers have initiated positive changes in pedagogy, particularly modes of learning and the strategies of teaching. The 'received wisdom' is that learners are supposed to be more advanced in using technology compared to the teachers. Therefore, the needs of the learners have been diversified having a belief that traditional modes of instruction need to be assisted by the regular use of applications of technology. This academic environment has challenged traditional methods of teaching and learning and resulted in some innovative ways of language teaching and learning.

The word *technology* has been linked with e-learning, and often used by itself when it is best to qualify it as *digital technology*. Prior to the terminology of *e-learning* emerging, many other terms were common–for example, 'Computer-Based Training (CBT)', 'Internet-Based training', Computer-Supported Collaborative Learning (CSCL), and 'Web-Based Training' (Oye, Salleh & Iahad, 2012). When *e-learning* emerged, it was adopted widely with many definitions proliferating. Typically, e-learning has been defined as "technology-based learning in which learning materials are delivered electronically to remote learners via a computer network" (Eldeeb, 2014). Following the impact of Covid-19, many educational institutions are now experienced at this. However, the 'readiness' of institutions has been discussed for decades (Favretto, Caramia & Guardini, 2003).

The concept of e-learning is relatively noble in South Asia in higher education. It ensures access to education through the use of information technologies. The enabling aspect of e-learning is anyone can explore new innovative ideas and multiple resources and learn aspects of independent or 'self-directed' learning. With the advancement of technology, it has become feasible for everybody to get access to learning anywhere. It is equally useful for the teacher educators in shaping their classroom pedagogy as well. Teaching materials are enriched and easily accessed by their target group with the judicious use of technologies. On the other hand, the use of such e-learning technologies and tools fosters learner autonomy. It is widely reported that information and communication technologies can encourage learners to make progress in their foreign language learning and motivate the learners positively and creatively (Dawadi, Giri, Simkhada, 2020). Furthermore, appropriate use of e-learning technologies provides adequate exposure and authentic materials. This is equally useful to Nepalese teacher educators and learners at their place. Teacher educators need to cater for two future needs the dynamics of change in their field and in their professional life (Mason, Shaw, & Zhang, 2019). There is no doubt that students significantly nurture their language skills through the use of advanced synchronous and asynchronous e-learning tools such as podcasts, blogs, wikis, streaming audios, streaming videos, web conferencing and online conferences. In addition, the use of such tools, as feasible in the classroom, can strengthen a teacher in shaping their professional identity (McDougall, 2010) and personal technical expertise as well. These tools serve as a catalyst for the balanced development of EFL students' language skills and sharpen the teachers' teaching skills and content. The rapid growth in the use of learning technologies, particularly the use of web-based technologies and communications has offered educators many more opportunities to investigate the most suitable learning environments for their students' learning preferences.

This research concentrates on exploring the critical incidents, including both success and stories of struggle of the teacher educators. They have successfully used the different applications of technology in higher education to foster interaction among the students. The major objectives of the study were to explore the innovative teaching strategies in teaching English in the foreign language context by university-level teachers in shaping their professionalism and pedagogical practices. The other objectives include exploring the possible challenges faced by them along with the possible strategies. Thirdly, it is helpful to recommend some pedagogical implications based on findings.

2. Methodology

Mixed methods involving triangulation of data collection was used. All the participants completed a pre-survey based on the Technology Acceptance Model (TAM) by Davis (1986, 2011). The teachers' self-initiatives were observed based on their efforts made to support their students. Teachers then were engaged in a short telephonic interview to know what efforts have been made to support the learners in their classroom as a baseline study. They were asked about their motivations, efforts that they made in integrating technology in language classroom. The recorded interview was transcribed, coded and questionnaire was designed based for the further exploration. Then, the open-ended questionnaire was sent through an online survey focusing on the benefits of ICT use for teaching and learning, perceived usefulness, and behavioural intention to use technology as a part of Technology-Integrated Pedagogy to reshape their professional identity.

Participants

There were seven teacher educators from three provinces: Gandaki, Bagmati and Karnali provinces of Nepal who were inquired about using interview narratives in formal and informal settings (as required) and the researcher explored their practices in the real field with available applications used by them or the use of technology integration in their classes maintaining the ethical considerations.

Research Design

The research design shows the overall strategy that the researcher chose to integrate the different components of the study coherently therefore effectively addressing the research problem. Among several research designs, a narrative inquiry approach was adopted. Narrative inquiry is the process of gathering information for research through storytelling and exploring one's experiences. It is a research methodology that is growing in acceptance and practice in such disciplines as nursing, medicine, law, especially organizational studies, therapy in health fields, social work, counselling, psychotherapy, and teaching for sharing human stories of experience (Webster & Metrova, 2007). Like other methodologies, the narrative inquiry "inquires" into or asks questions about and looks for a deeper understanding of particular aspects of life experience, in the present case the life of teachers.

Connelly and Clandinin (1990) note that "humans are storytelling organisms who, individually and collectively, lead storied lives. Thus, the study of narrative is the study of the ways humans experience the world." People's lives consist of stories. It is the interdisciplinary study of the activities involved in generating and analyzing stories of life experiences (e.g., life histories, narrative interviews, journals, diaries, memoirs, autobiographies, and biographies) and reporting that kind of research (Schwandt,1994). Narrative inquiry is unique in its study because it reveals life experiences through narratives or life stories. Moreover, narrative researchers hold in common the study of stories or narratives or descriptions of a series of events (Pinnegar & Daynes, 2007, p. 4). In addition to the above discussion, I reflected further on the critical incidents in using digital tools in the language classroom of EFL teachers through a constellation of images. There are diverse ways that researchers study these stories or sets of images. narrative researchers often analyze and interpret the stories that they gather and write by drawing them from philosophical and theoretical ideas about how we think through the story and tell about our lives using culturally available narrative models and even live our lives according to these models.

Like other forms of qualitative research, narrative inquiry often involves coding field texts (e.g., interview transcripts, letters from the participant to the researcher) for themes or categories. In this research, I used major themes or categories to a story (or retell or develop a meta-story) from the field texts. This new story may be structured around a chronology of events describing the individual's past, present, and future experiences and situated within a specific setting or context (Creswell, 2012). As narrative inquiry emphasizes relationships or collaboration between the researcher and others, I focused on the teachers' experience and professional practices, challenges in using digital applications for their professional and classroom interaction. I explored the emergent stories and negotiated their meanings with informants (Creswell, 2012), and share work-in-progress or profession with other narrative researchers (Clandinin & Connelly, 1990). As many narrative researchers emphasize the importance of learning from their participants, the focus was laid on the participant's stories in relation to their professional practices in higher education.

3. Data Collection and Analysis

Telephonic interviews, questionnaire and observation are the main research tools used in my research. An interview is the best research tool to obtain a snapshot of teachers' experiences, attitudes, and practices on the research topic. At first, a semi-structured interview was conducted with the target participants. Then voluntarily interested participants were invited for an interview. The series of interview was conducted to elicit the data as one or two interviews may not be sufficient to avail their experience and grit in using the digital applications. Secondly, the works that they have done or the articles that they have written based on their success stories or challenges were explored. If the permission is accessed by them, the snapshots of their successful sharing were kept in the research.

The systematically collected data were analyzed, interpreted, and presented as several themes. Quantitative data obtained from the close-ended questionnaire were presented based on the themes generated from the data in line with research objectives. In addition to this, qualitative data obtained from focus group discussions were coded, counted, and analyzed carefully for classification, summarization, and tabulation. the major discussion on the innovative teaching strategies in teaching

English in EFL classrooms challenges faced by the teacher educators and pedagogical implications from the data elicited.

4. Summary of Findings

The major discussion was on the innovative teaching strategies in teaching English in EFL classrooms, challenges faced by the teacher educators and pedagogical implications from the data elicited**.** As summary evidence, teachers had the positive and inspiring experience to integrate technology to motivate their students and bring changes to their professional identity. Although they were forced to learn new technologies to cope with the pedagogical shift, they felt happy later when they had positive appraisals from their students. Following sections describe these findings in detail:

Innovative strategies in teaching English in EFL classroom

There were several strategies, like discussion, the best selection of technology applications, access to information, thinking of alternative means, offline tasks, grit in oneself and assessing the effectiveness of the use of technology that English as Foreign Language (EFL) teachers have explored themselves, particularly at the university level. This helped them to explore their skills and create their professionalism in reshaping their pedagogical as well as content knowledge. In eliciting the data from the open-ended questionnaire and interviews, it was found that several new technological and pedagogical skills were learned for virtual teaching, and these reshaped their identity (Sapkota, 2021) as a teacher in an EFL classroom. During the COVID-19, they were forced to learn a few ideas regarding the use of technology. When a difficult situation like a pandemic or epidemic occurs in our context, there are avenues to explore new avenues (Kong, Jager-Biela & Glutsch (2020). Having a similar situation, the pandemic period made to be aware of new technology to the teachers. They learnt new strategies for online teaching and also gradually it's been effective. The research included open-ended questionnaire to share their stories in using technology, practices and reflections. Here are few of them:

> *Narrative 1*
> *There are many things to name that I have explored during and after the pandemic but particularly speaking, I learnt how efficient online tools can be in delivering the lesson to the students. The best session to name was by Stephen Krashen.*
>
> *Narrative 2*
> *Instead of the lack of internet access, apply different strategies to be in touch with the students; like phone calls, leaving voice messages in messenger and giving them tasks and asking them to send voice messages regarding the given tasks when I am in the physical class.*
>
> *Narrative 3*
> *I learned various web tools and developed my skills in IT. I learnt Nepali typing, Excel and other tools useful for ELT class. I learned to be familiar with digital literacy and using ICT in education. Besides that, I got opportunities to take part in several online/virtual events/webinars/conferences from which I received a lot of knowledge and experiences. I have learned amazing skills in using YOU TUBE videos to my advantage. Students feedbacks are quite amazing on my presentation*.

Overall, the teachers decided how often they could blend technology in the classroom. Technology helps to get access to authentic sources and an opportunity for alternatives (N,2). It is essential to know when and how much to blend technology in the classroom. Considering the context, level of students, access and knowledge of specific applications is a basis to consider before we use technology. A teacher needs to explore web options to develop confidence in integrating technology (N,3). The teachers suggested that advanced preparation (N,1) and technical knowledge in integrating technology determine its effectiveness as real engagement. The study of Sapkota (2021) relates his reflective writings on how we grow and learn from our own learning in using technology is similar to the stories of the teacher in this study.

Challenges faced by the teachers and addressing those challenges

The second objective of the study was concerned with the challenges faced by the EFL teachers in using technology and the way forward they used to address those challenges. The study tried to explore the major challenges that are faced during their classroom discussion in using technology and the way they overcome those challenges. From the survey and discussion, the following common challenges were identified, such as the challenges of employment opportunities, economic depression, and mental tension.

Narrative 1

I am keenly interested in professional development however the economic hurdles always revolve around my mind. When I try to solve this huddle, I need to teach as many classes as I can. I get tired while teaching and get busy with those classes. Then, the idea of academic writing, and publication dies and remains simply a hope in my life which may or may not be fulfilled further.

Narrative 2

I created a group with students in messenger and shared exercises, and useful materials and communicate with them. I learned to use the digital tools and by using them I am now able to be with my students. The ways to overcome those challenges are: Adopting alternative ways of teaching methods for teaching and learning activities, spreading awareness among people by showing different related videos and asking them to hear news about the Covid19 situation at the international level and national levels.

Narrative 3

One-way online teaching could turn out to be boring or monotonous during the COVID-19 pandemic. However, I found myself in a comfort zone very soon as I discovered and learned using various digital learning tools and techniques, like; Google classroom, quizizz, playposit, padlet, Google tools, etc. that helped me to make the online classes very interactive and full of fun. I learned many of these tools during the online training conducted by NELTA. As I started using these tools in my classes, I got various opportunities to share my learning with other teachers too in various sessions of training and workshops. The use of technology in my class helped me to grow professionally and earn new and better recognition at the local level.

Therefore, technology has brought positive aspects to professional identity despite economic huddles in the EFL classroom (N, 1). In addition, there were several challenges teachers faced in using technology, like time management, employment opportunities, frequent power-cut, low bandwidth, economic depression and mental tension. It is essential first to reflect ourselves how technology works before we use it in the classroom (N, 2). Access to information helps in the acceptance of technological changes and improves their affective, cognitive, identity, and social growth capabilities when the faculties cultivate their network of learning (Prestridge et al., 2021). Despite having challenges, technology helps in creating new knowledge as a part of continuous professional development. Prestridge et al. (2021) relate the concept of connected learning where personal interest or passion is supportive to assist other friends, colleagues and relates in online phenomenon.

Pedagogical Implications

Based on the narratives of the participants, it was found that the use of technology has created a positive impact on the pedagogical implications and has been successful to create social capital in the teachers' identity and has become a local driving force (Badar & Mason, 2020) in the professional development. The teachers' who knew technology applications were perceived as smart ones among others. There are some challenges in using technology such as low bandwidth, no electricity, no institutional support, and students with poor use of technological knowledge. However, the teachers started up with basic ideas in the classroom through their personal effort or learning through different professional associations.

Sometimes, they learned ideas 'how to do' from their own students. This helps the students to explore and make the teachers in their comfort zone of learning.

> Narrative 1
> *While I was dealing with the content in Grade XII-Hyperloop, I explained it in detail; however, I remained unsuccessful in making them convinced regarding the new transportation system. I used the technology. I downloaded a video showing how the hyperloop will work in the future. They got the point easily.*
>
> Narrative 2
> *Use of online materials to teach the text "Memoirs of my Visit to France". Because of the use of strange place names/plant names /other difficult vocabularies, it was very difficult to teach this text. Students would always be puzzled and know nothing even after teaching the text was finished. Later, I taught the same lesson using videos and pictures of these strange names, Students got the point. This changed the way I was teaching.*

The narratives above found that teachers need to be aware of mapping technology applications with the content of the textbook. It is essential to adapt the freely available resources based on the context we integrate technology (N,1 & N,2). The students even seem smarter than teachers when we use open or free sources. Therefore, the review made by Neupane and Joshi (2022) show that technology has an assert as human capital to accelerate the socio-economic development of the countries. In addition, the students expect more advanced learning and resources in the use of technology. The findings of Abubakre & Mkansi (2022) shows that motivation and capabilities to use digital technology in teachers not only by emotional and empathetic approach. This finding is similar in the Nepalese context as well.

5. Limitations and Further Research

5.1 Limitations

The most significant limitation of this study is that it focuses solely on teacher educators who have been engaged in their professionalism in Kathmandu and Pokhara valley. The research was limited to finding out teacher educators' professional practices on e-learning for developing language skills. Teacher educators on asynchronous tools of e-learning were the participants of the study. The research was limited to the teachers' experience and observations in using technology.

5.2 Further Research

The study explored the small-scale data from the university faculty regarding the way they practice and use technology. A further study can be made on the paradigm shift on how traditionally reluctant teachers change themselves in using ICT tools in their professional life. The students' achievements and experiences could be the additional area to be explored further. The impact of technology and the students' performance in their academic career is other issue to be explored. The support in learning from the peers or parental guidance integrating technology can be explored in further research.

6. Conclusion

The study was successful in identifying teacher success stories in using digital technology and coping with it successfully on their own. There were several innovative strategies, like determining the appropriate choice of technology applications, access to information and web resources, preplanning for alternative resources, offline tasks, promoting grit in oneself and assessing technical knowledge using technology that the teachers have adopted to bring changes in their classrooms. Despite having nominal institutional support, teachers explored the diverse use of technology from the several online tutorials to grow them. It is recommended to establish an ICT Support Centre in campuses to ease students in active learning and teachers enabling them grow professionally in technology.

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A Descriptive Study on the Translation of the Seamless Science Learning Model for Wider Diffusion

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Abstract: A seamless learning environment connects private and public learning settings where learning occurs across various contexts. The notion of seamless learning was connected to mobile learning, in which the use of personal mobile devices for learning was recommended to facilitate students' cross-contextual learning. In seamless learning research, there are crucial technical and pedagogical considerations that may affect seamless mobile learning. The challenge is that most local primary school students did not possess personal devices for learning, thus, hindering the efficiency of scaling up to more schools. In addressing the problem, this paper reported a qualitative descriptive study on a practice-oriented project to implement seamless science learning in the formal curriculum. Three primary schools in Singapore participated in this two-year project. The participating teachers in the project designed and implemented selected seamless science lesson units at their classes. A significant contribution of the project is that it informs what it takes to switch from one-mobile-device-per-learner to the techno-pedagogical model of seamless science learning. The lesson enactment using the model increased students' engagement levels and resulted in significant learning gains in the second year of implementation. Another important implication of the project was teacher professional development. Several participating teachers reflected on how their involvement in seamless lesson design and implementation impacted their teaching methods, including the willingness to use ICT for lessons and making connections with parents. However, the challenge to the widespread adoption of seamless science learning was reported. In fact, a seamless curriculum is more than redesigning lessons and incorporating technology into the lessons, it should be perceived as a culture, and learners must be enculturated to change their current learning habits of mind.

Keywords: seamless learning; science inquiry learning; social media; translation of learning innovations

1. Introduction

Seamless learning is when a person experiences a continuity of learning, and consciously bridges the multifaceted learning efforts, across a combination of locations, times, technologies or social settings (Sharples et al., 2012; Wong, 2015), ideally with the support of one-mobile-device-per-learner (1:1) (Chan et al., 2006). Over the last decade, our team's ongoing research and practice of the techno-pedagogical model of seamless science learning has yielded remarkable results. The initial pilot in a primary school between 2010 and 2013 (Zhang et al., 2010) showed that the participating students exhibited improvement in higher-order thinking skills (Looi et al., 2014) and self-regulated learning (Sha, Looi, Chen, Seow, & Wong, 2012).

Notwithstanding, there were challenges in the earlier teaching toolkits that hindered direct and efficient scaling up to more schools. The teaching toolkits were originally developed with the condition of 1:1, 24x7 setting. The majority of local primary school students, however, did not possess personal devices for 1:1 learning. Henceforth, we embarked on a practice-oriented project to derive an alternative techno-pedagogical approach to tackle the problem. This paper reports on a qualitative descriptive study on the project which took place between 2017 and 2018. The positioning of this paper is *descriptive*, not *evaluative*. Specifically, the roles of social media in connecting students' cross-contextual learning efforts in seamless science lessons will be explicated.

2. Literature Review

Seamless learning is one of the contemporary learning notions that address the needs of 21st century learning (Looi et al., 2010). With the defining feature of bridging multifaceted learning efforts across a variety of learning contexts, the objective is to foster a disposition in students to continually perform iterations of learning-application-reflection through recontextualizations of previously constructed knowledge (Wong, Milrad, & Specht, 2015).

The notion of seamless learning was linked to mobile learning by Chan et al. (2006) which advocated the use of mobile devices in 1:1, 24x7 settings to facilitate students' cross-contextual learning endeavors. The aforementioned paper launched the research field on mobile-assisted seamless learning worldwide. Yet the earlier perception of having 1:1, 24x7 as a mandatory condition for seamless learning has been challenged in recent years. Rather than taking it as a special form of 1:1 mobile learning, more recent literature argues that seamless learning is a modern learning notion in its own right – as an aspiration (Sharples et al., 2012), a habit-of-mind (Wong & Looi, 2011) or as a set of metacognitive abilities (Sharples, 2015). Thus, alternative technological support models have been proposed, such as the "division of labor" (DoL; i.e., using different devices, computer sets or even non-digital tools available at different locations) model (Wong, 2012) and the use of social media (Charitonos, Blake, Scanlon, & Jones, 2012; Laru & Järvelä, 2015).

Social media are increasingly used for supporting students' communicative and creative endeavors (Greenhow, Robelia, & Hughes, 2009). Social media support student-student and teacher-student interactions across multiple contexts through the same social network. Teachers may create topical social media items to solicit student responses in and out of classroom or encourage students to create social media on day-to-day encounters that trigger their curiosity (i.e., personalized learning). Subsequently, tapping on the reply feature, social media can mediate subsequent cycles of collective reflection and (re-)production (Lewis, Pea, & Rosen, 2010) or social meaning making (Wong, Chin, Tan, & Liu, 2010) (i.e., collaborative learning). Furthermore, social media-mediated seamless learning would free the students from relying on 1:1, as social media spaces are accessible by multiple platforms or devices (i.e., the DoL model).

3. Method

We worked with three primary schools in Singapore for implementation during 2017 and 2018. Our intention was to handheld the participating teachers in piloting the revised seamless science learning model in selected lesson units. Four cross-school professional development (PD) sessions were also conducted for the participating teachers to share and compare their designs and enactment experiences.

At the beginning of each project year, the teachers selected their class levels and curricular units to design and enact seamless science lessons. Table 1 summarizes the key information of the enactments in the participating schools. The cohorts are differentiated by school, year and level, e.g., school S1's P4 students in year 2017 is considered one cohort. Every cohort involved two classes. One or two lesson unit(s) were selected to be designed as seamless science lesson(s). Each lesson may last for about 2-3 weeks with intertwining in-class and out-of-class, and physical and online activities.

Specifically, during the study, we guided the teachers to design their lessons based on a set of streamlined seamless science lesson design principles of **C²FIP** (Wong, Looi, & Goh, 2017),

- **C**onnectivity of learning activities: Make the learning process cross-contextual - bridging formal and informal, individual and social, physical and digital settings.
- socio-**C**onstructivist inquiry learning: Facilitate an interplay of individual and collaborative inquiry learning. Encourage diverse "ideas" (Wong et al., 2021) from the students, and help them connect ideas, and later synthesize the knowledge.
- cross-contextual **F**ormative assessment: Different forms of student artefacts created at various learning activities can be used for the purpose of formative assessment. Teachers may design for systematically fostering the students' peer and self-evaluation skills across several lessons.

- leveraging resources in **I**nformal settings: The students' out-of-class living spaces may offer authentic learning resources that make their learning more relevant and meaningful.
- **Personalized** learning: Incorporate different learning modalities to suit different learning styles, and allow flexible learning pathways for individual students. Encourage interest-driven learning and group students with similar interests together to stimulate informal peer learning.

Table 1. *Summary of enactments taken place in the participating schools (Sx = school IDs; P3xx-y/P4-yP5-y = class IDs, with xx denoting the year, y denoting the semester, and P3, P4, P5 denoting 3rd, 4th and 5th Grade respectively; and Tzz = teacher IDs)*

School & year	Classes & teachers	Number of students	Lesson topic (month of enactment)	Social media tools used
S1, 2017	S1P417-1 (T11) & S1P417-2 (T12)	56	- light & shadow (July)	Padlet, Google Classroom
S1, 2018	S1P518-1 (T11) & S1P518-2 (T12)	53	- cells (February) - human systems (April)	Padlet
S2, 2017	S2P417-1 (T21) & S2P417-2 (T22)	43	- light & shadow (May) - heat (September)	Padlet
S2, 2018	S2P418-1 (T21) & S2P418-2 (T23)	50	- light & shadow (April) - heat (July)	Nearpod
S3, 2017	S3P417-1 (T31) & S3P417-2 (T32)	59	- heat (July) - human digestive system (September)	MC Online†
S3, 2018	S3P318-1 (T32) & S3P318-2 (T33)	59	- materials (April)	MC Online
	S3P418-2 (T34) & S3P418-3 (T35)	69	- heat (July)	MC Online

†MC Online is a Singapore-based Learning Management System. The Social Learning Wall module with social media features of MC Online had been deployed by S3 teachers in implementing their seamless science lessons.

A qualitative descriptive study on the lesson enactments was carried out for us to yield in-depth understanding of whether and how the **C²FIP** principles could be materialized. The research question that guides the descriptive study is:

> RQ: "How might the implementation of seamless science lessons at the participating schools impact the students' learning experiences and the teachers' instructional practices in the aspects related to the seamless science lesson design principles of **C²FIP**?"

To address the research question, the following set of qualitative data were collected for analysis, (1) Pre- and post-interviews with all participating teachers and selected students; (2) Video and audio recordings of in-class lessons; (3) Student artefacts posted online and peer discussions.

4. Findings

We uncovered important and somewhat consistent patterns across all three schools in students' practices of seamless science learning. This was done through applying (qualitative) constant comparative method (Strauss & Corbin, 1990) of students' online posts and peer comments, one-to-one interviews and class recordings. With a simple coding scheme that comprises the codes corresponding with the five design principles of **C²FIP**, we categorized the patterns/findings around these principles to see how the application of individual principles in the seamless science lessons have (or have not) transformed the ways the students learned. Some of the evidence span across multiple themes. We categorised the evidence in this way to make a better sense of the impact of the five design principles.

4.1 Connectivity of learning activities across contexts

All teachers but T34 viewed this most salient concept of seamless learning positively. Some of them perceived the learning approach as a vehicle to overcome the limited class time.

"Seamless learning is something that the students get to experience and understand the concept based on what they have discovered outside the classroom, with the help of technology."

(T32, pre-interview)

"For seamless learning … we are really trying to think of the way to make learning happen in the informal situation whereby something that is not intentionally build upon in class … we really try to engage our learners in different contexts, different environments, I think it will bring out learning more, rather than to say that every time we run into time constraint in school whereby everything is so rush. That is what I am hoping to achieve by seamless learning."

(T21, post-interview)

In the actual practice, the teachers designed their lessons which largely adhere to the cycle of "preparation at home" → "in-class learning engagement " → "out-of-class observations/ applications" → "online peer comments and knowledge co-construction". Such learning flows had effectively guided the students through the process of "recontextualization" in their learning journey.

Teachers T11, T12, T21, T32 indicated during the pre-interviews that they had experiences in implementing flipped learning (Flipped Learning Network, 2014) in the past. Thus, they incorporated such activities into their seamless science lesson plans, which had also influenced other participating teachers in their subsequent lesson designs. For example, a lesson may begin in students being instructed to view a relevant YouTube video or research online on a given topic at home prior to the first in-class lesson.

For example, in class S3P418-2, after being exposed to the basic concept of heat in the classroom, the students were tasked to take a picture at home or download a photo from the web that captured an example to show how heat was transferred, created graphical representations of the underlying mechanism or explaining it in their words, and shared them on the Social Learning Wall of MC Online to stimulate further discussions. The two examples in Figure 1 demonstrate how the students created multimedia artefacts to demonstrate their understanding in the concept in focus.

Figure 1: (left) a graphical representation on heat transfer with a web image; (right) a self-made video with caption to elaborate heat transfer (from class S3P418-2)

Such learning flows had resulted in the students' greater engagement in learning as they defied the "patterns" of regular science classes. As one teacher described,

"The engagement level was higher when I did seamless learning. It wasn't only because in and out of class, but during the lesson itself. … They anticipated, what are we doing today, why are we doing this. … I thought through different activities, we got the students to be very engaged, they felt very excited on what is coming up next. I asked some of them to give me feedback. They enjoyed the activity and would rather have this activity rather than teacher just telling them what to do."

(Teacher T11, post-interview)

4.2 Socio-Constructivist inquiry learning

The students were actively learning in the informal setting through online portals. They co-constructed knowledge by posting social media and commenting on their peers' works. That is, they made their ideas sharable for comparison and scrutiny, which led to negotiation of meaning. The benefit of bringing such activities online was articulated by a student as below,

> "The online portals enabled me to get the answer faster as I did not need to wait for classroom discussion. It was also interesting to read my friends' comments."
>
> (A student from class S1-P417-1, post-interview)

Examples of idea sharing, and peer comments are given in Figure 2. They are taken from the "heat" lesson at the class S1P417-1 where the students were asked to identify examples of heat sources.

Figure 2: Students' idea sharing and peer comments in the "heat" lesson at S1P417-1

Indeed, the key concept of this design principle is an integration of "social", "constructivist" and "inquiry" learning. In the participating teachers' lesson designs, inquiry learning usually takes place at in-class small-group experiments with well-defined procedures. Yet socio-constructivist learning is a broader term that covers not only such experiments but also other activities that require students to individually collect and interpret data in authentic settings or on the web, which constitute rich resources for subsequent knowledge co-construction. Such individual-to-social trajectory can be regarded as a trajectory of cross-contextual formative assessment (the next design principle). A participating teacher's comment reflects her understanding of this design principle,

> "With seamless learning, they *(students)* are able to do research; otherwise, they will have to go back to books and encyclopedia. Seamless learning helps to facilitate discussion. Deeper learning is not sufficient if just reading but do not provide comments."
>
> (T23, post-interview)

4.3 Cross-contextual Formative assessment

Various types of student-centered activities that required students to develop and share ideas, opinions or artefacts in the class-wide social space (either posting them online or presenting them in the classroom) have effectively served as the means for formative assessments. This is because the peers were then being encouraged to evaluate their views, compare alternative views from classmates, or provide feedback to improve their works. As the students deemed online social learning spaces as being semi-formal and low stakes, they were more willing to tinker and express diversified opinions.

> "They get to go online to discuss. To them it's like chit chatting with their friends, less scared to make mistakes because it's in an informal setting."
>
> (Teacher T24, post- interview)

Figure 3 presents two screen captures that illustrate such observations.

In a related note, a teacher explained why online discussion activities were valuable even if not all the students participated in out-of-school online discussion,

> "… I did get maybe 30-40% responses. From what they responded, I could screenshot and use it for classroom discussion. To me, it didn't matter how many people responded, just needed to capture important points and share with the class. I could use it as a teaching point. It was very clear to some of the students … I thought that one was actually a form of assessment because they checked on their own understanding."
>
> (T11, post-interview)

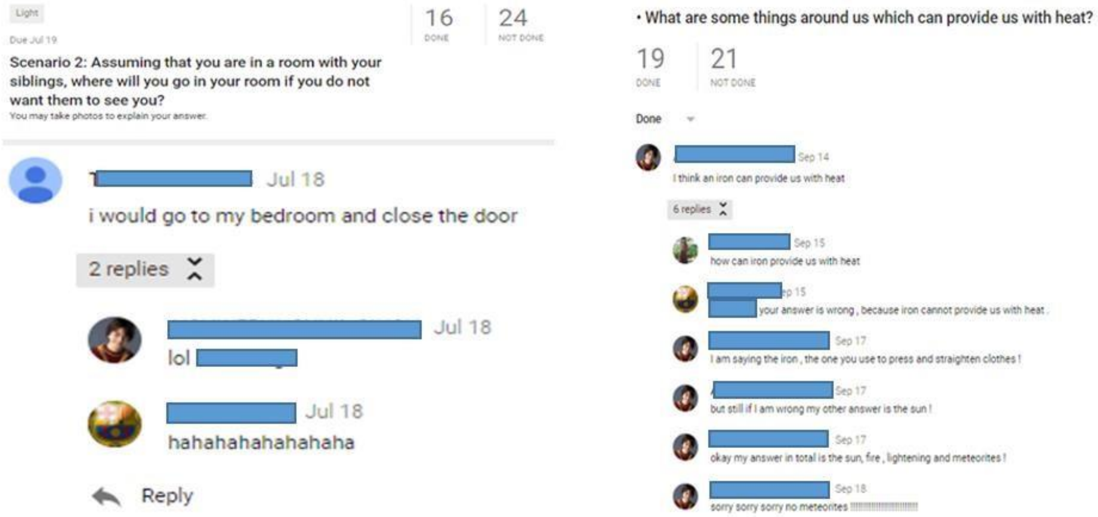

Figure 3: Students' easy-going and yet potentially constructivist peer interactions online (from class S1P417-2)

*4.4 leveraging resources in **I**nformal settings*

Teacher T21 shared his reflection on the value of leveraging resources in informal settings to advance students' learning. This is a means to foster their "eyes of science" in their daily lives. When being asked to compare inquiry learning and seamless learning, he posited,

> "I don't think I can compare. They are different things. Inquiry to me is I am giving the children the chance to talk, I am giving the children the opportunity to explore … *(For example,)* today I am going to teach about heat traveling from a hotter region to a colder region; so the children can think (*imagine*) that heat will always travel from a hotter to a colder region. But I think inquiry is getting them to explore. Did they observe that heat really travel from hotter to colder region? What was the observation that they made? What kind of measurement can they make to prove that what they have said is true? … In terms of seamless, I am just extending it to some other contexts whereby even be as simple as I may not need to conduct the lesson in my class. I would ask them to observe things that they have seen in their daily lives, and they can really connect with. So I think it is sort of like complementing one another."
>
> (T21, post-interview)

Indeed, most seamless science lesson designs required the students to collect data out-of-class which constituted rich resources for their subsequent deeper learning. Even if some of the student-generated materials were flawed, these would become the basis for peer review and knowledge co-construction (Wong et al., 2010). The examples in Figure 1 are two types of such data collected in informal settings. Another task under the same lesson required the students to conduct interviews with two family members or neighbors by asking them to compare the temperatures of the plastic handle and the metal blade of a pair of scissors, and to explain why the temperatures are different (see Figure 4).

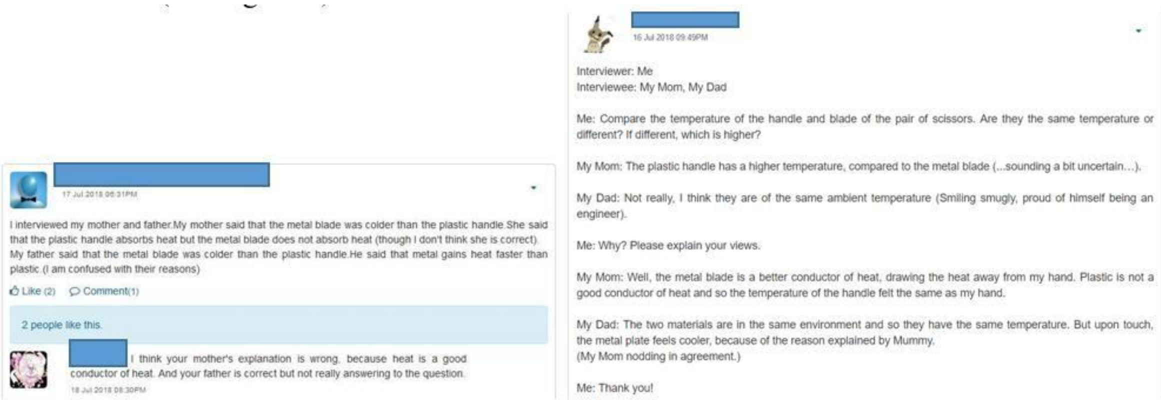

Figure 4: Students conducted interviews at home on the temperatures of handle and blade of a pair of scissors, and dissected their interviewees' views (from S3P418-2)

Other teachers have cautioned the enactment of such lessons. While the accessibility of ICT at home (despite a high percentage of students having that, there are always a few underprivileged ones around) has been a commonly known issue which teachers could find ways to work around, two teachers cited the parental support factor in enacting such learning journeys that privilege connectivity,

> "For those lessons we tried out, I really needed them to do the pre-lesson activities before the class sessions. It really depended on whether the parents were actively involved in such activities … some parents who cared enough would make sure their kids do, and feedback to me. For middle ability classes, the family is an important factor."
>
> (T11, post-interview)

> "… a lot of the students like to go to YouTube, and like to Google, because they are digital natives. But I feel that it could also struggle with their parents… I guess it was the parents who restricted the usage of the phones, because the parents have not seen the beauty, and say, 'I don't want to give you so long to surf.' … Maybe next year when we start again, it is useful to communicate to parents that, 'we are on this project where your child will...' If we have a meet-the-parents session at the right of the beginning, that could be a possibility."
>
> (T21, post-interview)

*4.5 **P**ersonalized learning*

We positioned this as an optional design principle in response to teachers' feedback, given the systemic priority of addressing the high-stakes examination syllabus and limited class time to facilitate interest-driven learning. Yet the teachers appreciated the rationale behind this principle and had been attempting to give students greater freedom in deciding what and how to learn whenever the circumstances allowed, which may constitute a small degree of self-directed learning (SDL). An excerpt of an in-class teacher-student dialogue demonstrates this (note: Student1 and Student2 belonged to the same group),

> T21: I would like you to write down what are you trying …
> Student1: To find out if the material takes the least time to melt the popsicle.
> T21: Okay, the material. So, you can write the aim of the experiment. Then, think about what are some of the materials you will need for making it?
> (Afterward, at group presentations)
> Student1: The aim is to choose a different type of bag is good for ice popsicles to not to melt for at least 15 minutes.
> T21: Okay. The aim is different. They have a time there. At least 15 minutes. So what are the instruments, what other additional instruments that you guys will need? (i.e., the teacher allowed the student group to set their own experiment goal and helped them to accomplish that) Student2: Instruments are thermometer, different type of bags, like metal, leather and foam. Ice popsicles, salt, Ziplock bag and plastic bottles.
> T21: Student2, what kind of instrument do they need? What are the variables that you have kept the same? Beside what they have said earlier? Student1: Room temperature
> T21: So that is environment, right?

Student1: Size of the bag. Volume of ice popsicle.
T21: Wait wait, they have one more, they have volume of popsicle. Okay we also need that to be the same. What else?
Student1: Temperature of ice popsicle. The environment. Amount of salt.
T21: Amount of salt. Why salt?
Student2: The salt can keep the ice don't melt so fast.
(The dialogue continued where T21's subsequent questioning made the students realise that salt was not needed in the experiment given the objective they had set.)

(The lesson on "heat" at S2P417-1, July 2017)

A teacher's observation may be an indication of an increased level of SDL among her students,

> "To facilitate independent learning, let's say in online discussion, if their friends stated a wrong fact, they would research why the friend was wrong and gave a correct concept to them. In the past, they wouldn't do it, because they wouldn't come prepared before lessons to answer the questions."
>
> (Teacher T12, post-interview)

Indeed, in general sense, SDL does not equal personalized learning. Nonetheless, the students' practice of SDL may promote personalized learning, particularly with the teacher's support to optimize an individual student's self-determined learning effort as such for the latter's learning need.

5. Discussion and Implications

A key contribution of the reported project is an improved understanding of what it takes to transform the school-facilitated seamless learning practice from 1:1 to the DoL model. The results of our study show both promises and challenges. In spite of an earlier doubt that the lack of learners' personal devices would undermine the expected effectiveness of seamless learning, our "division of labor" lesson plans were in general adhering to the five design principles of C^2FIP and managed to increase students' engagement level (because of the novelty in the learning activities and the use of ICT). The teachers have also acknowledged the value of seamless science lessons upon the end of the study, as they observed their students' positive changes in various aspects. Thus, the study provides evidence support that seamless learning based on the DoL model is a feasible and a good compromising technological model for 1:1 in seamless learning, given the current conditions in typical primary schools in Singapore and other countries.

Another key implication pertaining to teachers' growth lies in some participating teachers' reflections on how their involvement in seamless lesson design and enactment had impacted their own teaching styles which might potentially spill over to their routine teaching, such as "talking less, letting students talk more", inclination to use ICT for lessons, and engagement with parents. Their in-depth exposure to advanced pedagogical models which is novel to them may constitute opportunities for them to think out of box, to reflect upon and challenge their extant beliefs about their practices of teaching – in how they interact with their students, assess their students, be more sensitive to their students' needs, and be more adaptive in both their lesson designs and actual teaching, etc.

Implementation of the novel pedagogical model in the participating teachers' classes might also provide opportunities for students' talents or competencies, particularly relating to soft skills or ICT literacy, to be manifested in regular lessons and standard class assessments. The teachers would then rethink their previous assumptions on their students' abilities and therefore adapt their lesson design or enactment accordingly. Thus, regardless of whether they continue to implement the pedagogical model beyond the study, their involvement in the study is valuable to them.

A profound challenge for wider diffusion of seamless science learning is the schools' and teachers' willingness and readiness to implement longer term and more frequent seamless lessons. Indeed, seamless learning is more than redesigning lessons and putting technological resources in place. It should be regarded as a culture, and, as advocated by researchers in the field (Milrad et al., 2013), the learners need to be enculturated to transform their existing disposition in learning.

Specifically, students need to be fostered in the skills of SDL and collaborative learning to maximise the effect of seamless learning. Based on our lesson observations and teachers' feedback, the students had performed satisfactorily, if not thrived, in the aspect of collaborative learning (i.e., active online discussions with diversified opinions). Yet there is room for enhancement in their SDL – albeit isolated cases of students proactively sharing new artefacts or opinions in the online spaces beyond the seamless science lessons, which had not yet become a sustainable culture. High performing students might be more proactively Googling and sharing additional information (another form of SDL) to enrich the online discussions, while their counterparts were instead leveraging more on their existing prior knowledge (or misconceptions) in the discussions without carrying out additional research. If they were enrolled in a more intensive seamless curriculum instead, the "right" culture could be fostered. We argue that when both teachers and students become adept in seamless curriculum, more time would be saved, and the learning effects would be elevated.

6. Conclusion

This project addressed the adaptation of the seamless science learning model to fit the conditions of typical primary schools in which the constraint of the requirement of 1:1 was removed. It has illustrated that with the researchers' guidance, primary science teachers can be empowered to design good seamless science lessons that adhere to techno-pedagogical design principles. Research data analysis showed evidence of student learning as well as teacher growth in designing and enacting seamless science lessons (Voon, Wong, Chen, & Looi, 2019; Voon, Wong, Looi, & Chen, 2020). The project findings have led us to usable knowledge in terms of a deeper understanding of K-12 school-based seamless learning, and how to bridge such practices from the use of 1:1 technology to a DoL model.

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The Acceptance of Online Continuous Professional Development (CPD) among Remedial Education Teachers in Pahang, Malaysia

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Abstract: This concept paper aims to study and understand better the Special Remedial teachers' acceptance of online continuous professional development in Pahang, Malaysia. This study is based on Technological Acceptance Model, and six predictors are chosen. This correlational study will involve a minimum of 215 samples that will be selected using simple random sampling.

Keywords: online continuous professional development, technology acceptance, special remedial teachers

1. Introduction

The Malaysian Ministry of Education (MOE) has a long history of combating literacy and numeracy issues in our education system. In Malaysia, a Special Remedial Program (SRP) is available for level 1 primary school students who have difficulty mastering the 3R's (reading, writing, and arithmetic) complex skills due to environmental factors (Kasran et al., 2012), such as the pandemic we are currently facing. It is taught by Special Remedial teachers (SRT) in Malaysian primary schools and focuses on remedial Bahasa Melayu and remedial Math.

However, SRP still requires attention and improvement because of the need for professional development of remedial teachers in Malaysia (Kasran et al., 2012). It is found that teachers need appropriate techniques to create teaching materials that are easy to understand and follow by level 1 students (Ahmad Saifudin & Hamzah, 2021). Hence, teachers have adopted continuous professional development (CPD) through various digital educational platforms such as Moodle, Zoom, Google Classroom, and Edmodo, which will allow them to keep updated about the latest issues of English teaching through discussing and sharing problems and solutions with other teachers (Magdaminkhodjaevna et al., 2020).

Online continuous professional development is the systematic maintenance, improvement and broadening of knowledge, understanding and skills, and the development of personal qualities necessary for executing professional duties throughout the individual's working life that is done online either synchronously or asynchronously. In keeping with the twenty-first century, advanced information and communication technologies have made it easier for Malaysian teachers to access online professional development at any time and from any location, such as the Open Learning Website. Open Education Resources (OER), e-*Pembelajaran Sektor Awam* (EPSA), and e-*Pembelajaran Melaka* Autonomous Blended Learning System (eP-MABLS). Then, SPLKPM was created to include educational opportunities and credit hours. Thus, teachers can self-manage their training and independently acquire new skills and abilities online, from any location and at any time. Those who have not completed the seven-day training course may also take this initiative to comply with current regulations.

However, with any innovation, when power is transferred from planners to teachers, significant changes can be predicted at the implementation stage of such audacious top-down educational reform innovations (Konting, 2016). Additionally, it is found that the virtual learning medium is less popular among teachers due to a lack of knowledge and skills to handle technology-based lessons (Ahmad Saifudin & Hamzah, 2021). Moreover, even if schools have technological equipment, teachers are ultimately responsible for curriculum implementation through educational technologies (Konting, 2016; Koyuncuoglu, 2021).

Thus, it raises the question of SRTs' acceptance of online CPD. How will SRTs in Malaysian primary schools perceive and respond to Online CPD? Which factors will facilitate and impede them from accepting Online CPD? These questions must be investigated because teachers must possess adequate pedagogical, technical, and content-based expertise and an understanding of the interactions between these three types of knowledge to effectively promote student-centred education (Koyuncuoglu, 2021; Schoepp, 2005).

2. Research Objectives

Numerous studies have established the value of ongoing training to improve teachers' performance which is critical for effectively transforming a lagging school. Studies show that effective CPD is CPD that is implemented continuously, contextually, school-based and educator-centred (Blau et al., 2011). Covid-19 pandemic outbreaks have also interrupted and altered the educational sector for most of 2020 (Dhawan, 2020). However, there is still a lack of studies that explores SRTs' acceptance of adopting online CPD. Therefore, to better understand SRTs' intention to adopt Online CPD, this research is designed to determine SRTs' behavioural intention to learn online and the conditions and factors affecting the teachers' behavioural intention to learn online, thus will provide empirical evidence to the existing knowledge. Accordingly, the following research questions will be addressed:

1. What is the extent of SRTs' acceptance of online CPD?
2. What are SRTs ' perceived ease of use; perceived usefulness; attitude; computer self-efficacy, and social factors towards SRTs' behavioural intention towards online CPD?
3. What are the relationships between SRTs' perceived ease of use, perceived usefulness; attitude; computer self-efficacy and social factors towards SRTs' behavioural intention to teach online?

3. Conceptual Framework

This research will use the Technological Acceptance Model (TAM) as its framework because it is a well-established and reliable method for predicting user acceptance (Venkatesh & Davis, 2000). It was proposed to forecast user acceptance and adoption of new computer applications (Davis, 1989). It has progressively been utilised to measure the intent to use specific innovations or services (Wang et al., 2015).

The model suggests that the system and behavioural intention (BI) can be explained by the following constructs: perceived usefulness (PU), perceived ease of use (PEU), and attitude towards using (ATU) to use the system. TAM has two primary components: perceived usefulness (PU) and perceived ease of use (EOU). PU refers to the extent to which a user perceives a product's or service's usefulness. Meanwhile, EOU is the extent to which the user believes using the tool will be effortless. Prior research also identified other external variables as additional predictors of intention to use a system. As a result, for this research, computer self-efficacy (CSE) and social factors (SF) have been chosen as the external factors to determine their correlation with BI. Figure 1 is the proposed conceptual framework for this study.

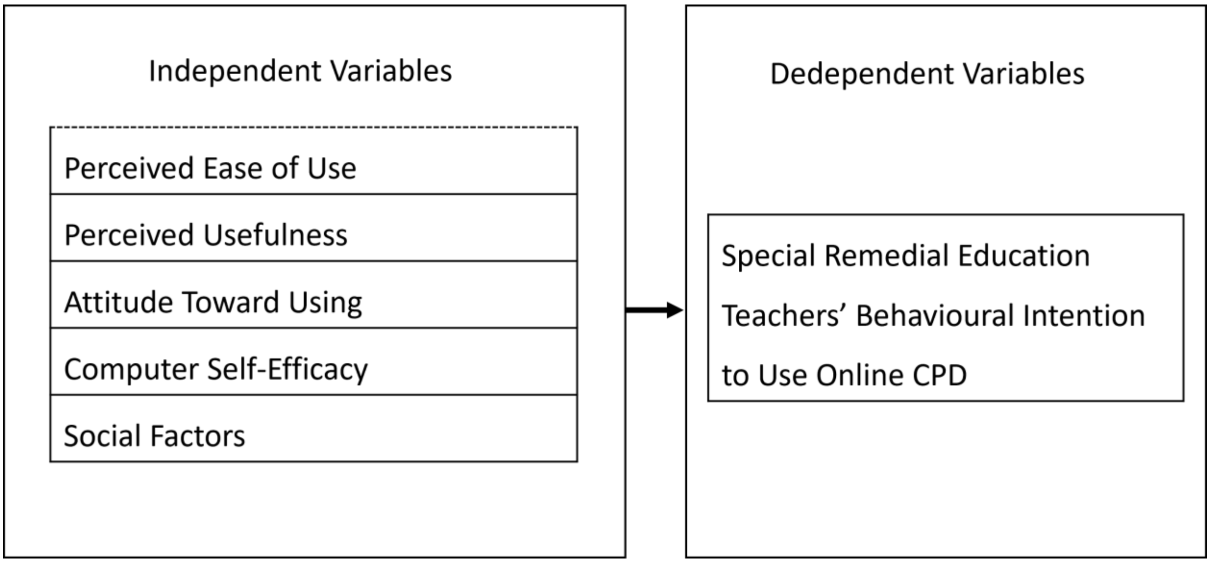

Figure1. Proposed Conceptual Framework

4. Research Methodology

4.1 Research Design

The researchers will begin by identifying the sample required for this study and subsequently develop the appropriate questionnaires for the survey. Causal comparison and correlational research designs will be used in this study. The causal comparison design is a research method that compares at least two groups that differ on a particular subject. The subject and case studied emerge naturally from this research design, unaffected by the researcher's intervention or manipulation. The researcher has no influence or intervention in this design's comparison groups.

4.2 Population and Sample Size

A population is a group of individuals who have the same characteristic. In inconvenience sampling, researchers have easy access chosen as the sample (Cohen et al., 2002). Hence, the research participants in this study will be recruited using convenience sampling, consisting of SRTs of the 542 primary schools in the state of Pahang. Krejcie & Morgan's (1970) table was used to select the sample size of this research. Thus, 215 respondents will be chosen as the sample for this study.

4.3 Sampling Technique

The researcher will use simple randomised sampling for this study, consisting of Remedial Education teachers of Pahang who teach in Sekolah Kebangsaan and Sekolah Jenis Kebangsaan. The researcher believes that the sample from this population can represent the population of Remedial Education teachers in Malaysia because Malaysian Education System is centralised. Thus, survey participants will be selected randomly from the target population of SRTs from Pahang to eliminate sampling errors and ensure appropriate population representation,

4.4 Data Collection and Analysis

This non-experimental quantitative study will employ the administration of a structured online questionnaire via Google Forms. The entire data collection process is expected to last six weeks. The research will develop the survey instrument based on the research questions guiding this investigation. After the instrument is completed, a pilot study will be conducted to eliminate ambiguity in the questions and test the instrument's reliability and validity. If flaws are discovered during the pilot test, the instrument will be redesigned and revised until it is acceptable. The instruments were then administered to the target population; once completed, the surveys were collected for data analysis.

Exploratory data analysis is the primary step to analyse data using inferential statistics such as MANOVA, Pearson's Correlation (r) or Multiple Linear Regression Tests. It will be done to identify if there is data loss or outliers. It also can identify whether the assumptions for normality, linearity, homoscedasticity and independent observation are met. Descriptive and inferential statistical analyses will be performed to address the research questions.

Descriptive statistics provides an outline, summary or understanding of a specific dataset. Meanwhile, inferential statistics aims to transcend the immediate data and draw inferences about the population characteristics based on the samples. Therefore, Descriptive Analysis will be employed to analyse research questions 1 and 2. Pearson correlation will be used to analyse question 3 to examine the relationships between the predictors and dependent variables involved in the study.

5. Proposed Contribution

The study of the acceptance of technology is crucial to effectively adopting any informative system (Buche et al., 2012). Despite the recent flood of online courses for teachers within educational organisations, remedial education teachers' acceptance of Online CPD is not guaranteed. SRTs are tasked with educating those who need proper care and remediation. However, there is still a lack of studies on SRTs concerning technology adoption. By disclosing teachers' intentions and attitudes toward technology, educational administrators will have enough information to foster and improve teacher-learner acceptance of ICT tools for current and prospective users (Lee et al., 2001). This study will answer the research objectives by looking into the correlation between perceived ease of use, perceived usefulness, attitude, computer self-efficacy, and social factors towards SRTs' behavioural intention toward online CPD. Thus, this research seeks to add to the existing body of knowledge regarding remedial education teachers' Technological, Pedagogical and Content Knowledge and how it relates to the acceptance of Online CPD.

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Computer Assisted Pronunciation Training (CAPT): A Systematic Review of Studies from 2012 to 2021

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Abstract: Learners' skills of pronunciation are crucial linguistic and communicative competence in second or foreign language learning. Computer-assisted pronunciation training (CAPT) emerged since the early 1970s and was studied by researchers from both linguistic and non-linguistic field. CAPT has been increasingly implemented in the field of language teaching and learning due to the advantages of Web 2.0 technologies. CAPT systems are used to improve learners' pronunciation in target language. A systematic review of empirical studies over the recent years is called forth in order to arouse broadened knowledge and provide new insights in this area. This study systematically reviewed 54 empirical articles on CAPT published in nine representative SCI, SSCI, or CSSCI-indexed journals from 2012 to 2021 in the field of applied linguistics and computer science. This research revealed the yearly publications, research sites, target languages, and research settings of CAPT and further analyzed the research methodologies of the selected articles. The present study revealed that the majority of studies employed quantitative research method and only one article adopted qualitative method. Finally, it summarized the common systems used in the process of pronunciation learning and found mobile app-based systems are most-widely used in recent years. This systematic literature review contributed to the knowledge of the current research status, and it also provided some insights for future research and development of CAPT.

Keywords: Computer-assisted pronunciation training, language learning, pronunciation learning, systematic literature review

1. Introduction

Language teachers have faced the dual challenge when helping learners produce target-like L2 pronunciation. One is that the perception of sounds is a subjective experience. Speech sound is transient and invisible, making the instruction of pronunciation difficult (Liu & Tseng, 2019). Another is that the teaching of pronunciation to language learners is in a less significant position since the curriculum is still dominated by other aspects of the language competence and teachers themselves usually do not have adequate training in phonetics (Pennington & Rogerson-Revell, 2019). Therefore, efforts should be made to apply technology to help language teachers instruct pronunciation.

Computer-assisted pronunciation training (CAPT) is a crucial component of Computer Assisted Language Learning (CALL) and it concentrates on the evaluation of pronunciation proficiency or correcting pronunciation errors. Technologies like computerized visualization feedback have usually been employed for pronunciation training. Recently, digital technologies have offered great potential for pronunciation training. The rapid evolution of technologies makes it possible to integrate pronunciation training with advanced technologies including automated speech recognition (ASR) and artificial intelligence (AI). Employing ASR, CAPT can provide user-friendly visualizations for pronunciation features and feedback on learners' pronunciation.

In essence, CAPT resources have the potential to provide an individualized and self-paced learning environment with a wide range of multimodal materials as well as opportunities for immediate, customized feedback (Revell-Rogerson, 2021).

2. Literature Review

Computers have been used for teaching since the 1960s and educational software was developed ever since. Computer systems used for improving language learners' pronunciation occurred in 1970s (Agarwal & Chakraborty, 2019). Kalikow and Swets (1972) designed the first software tool for the instruction of pronunciation named automated pronunciation instructor system in the early 1970s. CAPT systems received considerable attention in applied linguistics community since its existence because such systems give learners the opportunity to practice pronunciation on their own pace and significantly reduce teachers' pressure in instructing pronunciation (Richards, 1986). Students receiving pronunciation training in classroom tend to be afraid of having their pronunciation corrected in front of their peers. CAPT systems in this respect can help reduce students' anxiety and provide them with personalized feedback or suggestions and allow students to avoid face-to-face training with tutors which might be embarrassing for them.

Although CAPT as a branch of CALL existed in 1970s, the actual progress in CAPT for pedagogical purpose happened only since the beginning of the 21st century. Since digital technologies such as computers, laptops and smartphones are ubiquitous nowadays, self-study with the help of these technological tools becomes possible. Some of these tools are becoming technologically sophisticated, and CAPT systems integrated with ASR and AI are available to teach and test pronunciation (Revell-Rogerson, 2021). These tools detect and diagnose mispronunciations in learners' speech, and then help them to correct their pronunciation (Agarwal & Chakraborty, 2019). The field of CALL has developed massively in recent decades, and interest specifically in CAPT has grown similarly, with a proliferation of research focusing on web- and mobile-based pronunciation learning (eg., Dai & Wu, 2021). In this literature review, the following three questions are used to guide the analysis:

- What are the general research trends of the reviewed studies about CAPT from 2012 to 2021?
- What are the research methodologies employed in the reviewed publications?
- What are the types of systems used in the process of pronunciation learning within CAPT context?

3. Methodology

3.1 The process of identifying journals

Because of the multi-disciplinary nature of CAPT, the researchers first searched studies from Web of Science (WoS) and IEEE *Xplore*. To explore research conducted in CAPT by Chinese scholars, we also included China National Knowledge Infrastructure (CNKI) as our database. After preliminary literature search, nine journals were selected from China and abroad. Four high-impact international journals were selected from WoS, namely *Computer Assisted Language Learning* (CALL), *ReCALL*, *Language Learning & Technology* (LLT), and *System*, all of which are indexed by Social Science Citation Index (SSCI). Two journals indexed by Science Citation Index (SCI) were retrieved, that is, *IEEE Access*, and *IEEE/ACM Transactions on Audio, Speech, and Language Processing*. The other three journals are Chinese journals indexed by Chinese Social Science Citation Index (CSSCI), namely *Technology Enhanced Foreign Language Education* (TEFLE), *Foreign Language Learning Theory and Practice* (FLLTP), and *e-Education Research* (EER). The present research adopted the systematic content analysis as the major method for reviewing studies.

3.2 The process of data coding and data analysis

Firstly, the author manually screened publications in recent ten years from the above nine journals by referring to the titles and the abstracts. Since all the selected journals are related to CALL, we first screened titles and the abstracts containing "pronunciation learning", "pronunciation training" as their key words and excluded review articles or commentaries. After reviewing the abstract and key words, we got 64 empirical articles. Second, we read the full articles to exclude ten articles either unrelated to pronunciation training or irrelevant to technology. Finally, 54 empirical studies concerning CAPT were identified for further analysis. Following the analytical framework proposed in previous studies (Chai, Koh, & Tsai, 2013), a coding scheme was defined to systematically review the general publication trends, current issues, research methodologies and CAPT tools in this field. The coded data for the systematic review consisted of quantitative and qualitative data. The social science analysis software, SPSS 22.0, was used to analyze the quantitative data. The qualitative data were categorized and summarized with the help of qualitative data analysis software, NVivo 11.0.

4. Results

4.1 General publication trends

4.1.1 Number of the studies published from 2012 to 2021

There are 54 empirical studies in total concerning CAPT published from nine journals in recent ten years. Of all 54 published articles, 44 were from English journals and ten were from Chinese journals. CALL (16 publications) published the largest number of studies in the past ten years, followed by LLT (11 publications), *System* (6 publications), and *ReCALL* (3 publications).

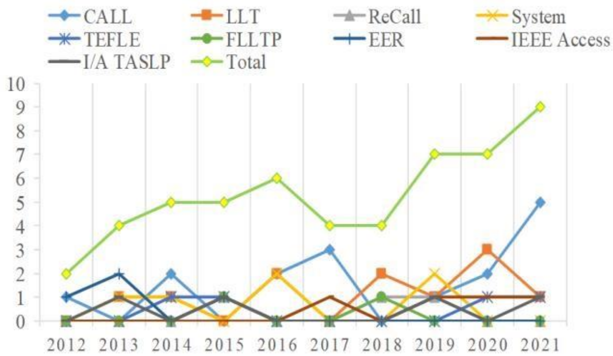

Figure 1. The numbers of reviewed publications in the 9 journals (2012 to 2021)

Over the past ten years, there has been a gradual rise in the total number of publications, and 2021 witnessed the largest number of publications (9 articles). Although CAPT is not a new topic and has developed for almost 50 years, the research about CAPT in specific is still limited. Thanks to the increasing intelligence of smartphones, more researchers focus on mobile assisted pronunciation learning, which explains why CAPT-related research has increased in recent two years. Due to the COVID-19 pandemic, many schools adopted online teaching, therefore providing the opportunity to improve students' pronunciation with online resources during school closures. For example, Jiang and Chun (2021) found that web-based training on English discourse intonation can effectively scaffold and benefit their English pronunciation.

4.1.2 Research sites and research settings of the empirical studies

It should be noted that all the all CSSCI-indexed articles (10 publications) were conducted by Chinese scholars in China, which probably explains why China ranked number one considering research sites of all the studies. Apart from ten CSSCI-indexed articles, only four international studies were conducted in China. As indicated in Figure 2, we found that scholars from USA (11 publications) and Taiwan, China (9 publications) published many studies related to CAPT in recent ten years. In addition, scholars from Spain, Canada, Japan and Poland also showed growing interest in this field.

As shown in Figure 3, the majority (34 articles) of studies were conducted in higher education settings, which shows the prominence of CAPT in higher education. College students are advanced language learners and have more sophisticated digital literacy compared with students in other degree.

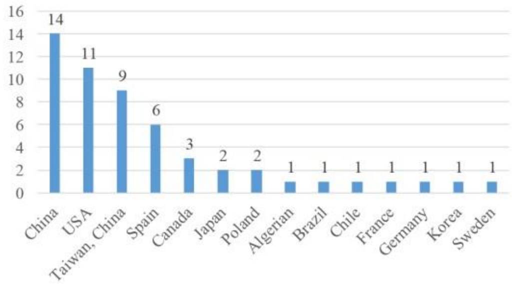

Figure 2. The research sites of the studies

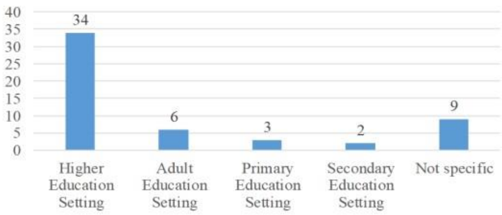

Figure 3. The research settings of the studies

Hence, they become desirable participants. There are six studies focusing on adult language learners who participated in online or distance language courses. Less attention has been paid on primary school students, with only three studies enrolling pupils as their participants. Interestingly, all of the three studies were conducted in elementary school in Beijing, and two of the studies were conducted by the same group of researchers. For example, Sun and his colleagues (2017) integrated a social media app named Papa into first-grade English classes and found that the use of such an app improved young learners' pronunciation in terms of fluency.

4.1.3 Target languages studied in the reviewed publications

As indicated in Figure 4, more than 60 percent (39 papers) of the reviewed articles targeted at the English pronunciation learning, indicating that English is the dominant target language in the reviewed articles. Since English is a foreign language in China, learners often face problems related to English pronunciation. As for CSSCI-indexed articles, eight out of ten were concerned about English pronunciation learning. Similarly, nine research conducted in Taiwan, China also focused on English pronunciation learning with the help of technology. The discrepancy between Chinese and English phonetics hinders Chinese students' accuracy in English pronunciation. Pronunciation is traditionally considered as a difficult part in EFL classrooms for both teachers and students in China, which explains the reason why a large number of studies conducted in China considered English as the target language.

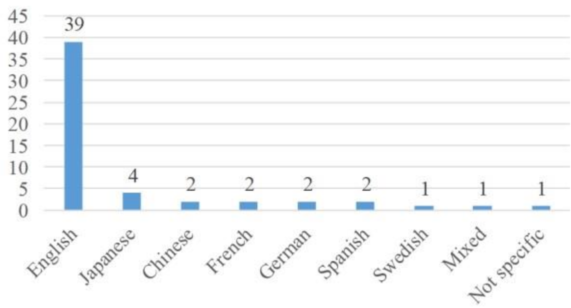

Figure 4. The target languages of the studies

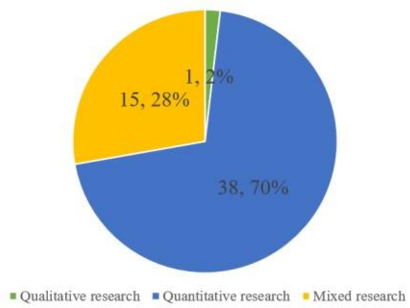

Figure 5. The research methods of the studies

4.2 Analysis of research methodologies

Among the empirical studies we reviewed, 38 studies (70%) employed quantitative research method, and 15 studies (28%) employed mixed method design. As indicated in Figure 5, only one inquiry adopted purely qualitative method. Drawing upon qualitative approach, Tsai (2019) investigated how students feel about the mediated assistance of CAPT, their difficulty and attitudes toward using technology for pronunciation learning.

Besides, most of the quantitative and mixed-method research adopted experimental- or quasi-experimental design with pre- and post-tests aimed at measuring the learners' pronunciation before and after the training. Experimental and quasi-experimental research designs examine whether there is a causal relationship between independent and dependent variables (Rogers & Revesz, 2019). It is especially appropriate in CAPT research. The mixed research design is advantageous in that students' learning effects and perceptions were captured by quantitative and qualitative data, therefore allowing a comprehensive account of both outcomes and experiences of the CAPT process

4.3 Systems and tools used to enhance pronunciation learning

Based on the framework of Agarwal and Chakraborty (2019), we further classified the CAPT systems into five categories, namely, app-based systems, visual simulation-based systems, AI-based systems, comparative phonetics-based systems, and game-based systems.

As indicated in Table 1, we found that app-based systems (16 articles) were the most frequently used systems of all 54 empirical studies. The ubiquitous accessible and flexible practices of mobile learning might contribute to the proliferation of research that adopted mobile apps as its tool for pronunciation training. For instance, Fouz-Gonzalez (2017) investigated the potential of Twitter-based pronunciation instruction and found that learners' pronunciation improved through the intervention based on Twitter.

Visual simulation-based systems (14 articles) provide computerized visualization feedback that helps learners better visualize, analyze and produce various aspects of L2 sound (Liu & Tseng, 2019). Hence, visual-based systems ranked second frequently adopted systems with sub-categories, such as speech waveforms and spectrograms, video feedback, and Praat (eg., Liu & Tseng, 2019;).

In terms of AI-based systems, ASR seemed to be the most prevailing tool since six papers used ASR. Although ASR was not originally developed for language learning, the advantage of ASR for pronunciation learning was identified. Dai and Wu (2021) investigated the effectiveness of ASR feedback in WeChat and explored the affordances of ASR in mobile-assisted pronunciation learning.

Due to the importance of segmental features to pronunciation learning, some researchers attempt to develop perceptual phonetic training system and found that such a system was effective in enhancing participants' perception of phonemic contrasts. The ongoing popularity of game-based tools like 3D virtual worlds have been successfully integrated into pronunciation courses with positive learning outcomes (eg., Grimshaw & Cardoso, 2018).

Table 1. *Systems and tools used for pronunciation learning*

Systems	Specific Tools	Number
App-based systems (17)	Website	3
	WeChat	3
	Twitter	2
	Papa	2
	Online podcast	2
	Facebook	1
	Skype	1
	Tell Me More	1
	MyET	1
	Multimedia resources	1
Visual simulation-based systems (14)	Waveform and spectrogram	6
	Video feedback	5
	Praat	3
AI-based systems (11)	ASR tool	6
	TTS (text-to-speech) tool	3
	Intelligent assistant	2
Comparative phonetics-based systems (5)	Segmental perceptual tool	3
	Pronunciation scoring tool	2
Game-based systems (4)	Self-designed game	2
	3D virtual world game	1
	Spaceteam mobile game	1

5. Conclusion

At present, the great potential of technology for pronunciation learning is undeniable. Employing the content analysis method, this study systematically reviewed 54 empirical studies published by nine Chinese and international journals focusing on the affordances of technology for pronunciation. A coding scheme and analytic framework was postulated to analyze the publication trends of CAPT. Besides, we analyzed research methodologies of the studies and found most of the studies employed quantitative research method. Finally, we summarized the popular CAPT systems and found that mobile apps were the most popular type of tools in recent years. This systematic literature review might enhance our understanding of current research status in CAPT, and provide some insights for future research and development of CAPT.

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Factors Affecting the Acceptance of Asynchronous Video-Based Learning among Malaysian Secondary School Students

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Abstract: The use of Asynchronous Video-Based Learning (AVBL) has garnered much discussion throughout the years. Several studies have reported the benefits of learning through videos; however, an in-depth understanding of students' intention to adopt AVBL remains unclear. Thus, to better understand secondary school students' intention to adopt AVBL in Malaysia, five predictors are selected for this study. These predictors, namely performance expectancy, effort expectancy, social influence, viewing attitude, and facilitating condition, are based on the Unified Theory of Technology Acceptance and Use of Technology (UTAUT) and Active Viewing Framework (AVF). Many studies have used UTAUT in research on the usage of videos in the classroom (Wijaya et al., 2022); however, research that includes students' viewing attitudes to study their acceptance of AVBL is still scarce. This nationwide study adopts the correlational research design involving 401 secondary school students. Samples will be selected based on the stratified cluster sampling method, and data will be collected through a structured online questionnaire. Descriptive and inferential statistical analyses such as Pearson correlation and Multiple Linear Regression will be used to understand the variables' relationships and the variables' proportion of variance in students' use of AVBL to support their learning. The results of this study may shed light on potential future plans for AVBL deployment in the classroom.

Keywords: Asynchronous online learning, technology acceptance, video-based learning, active viewing

1. Introduction

The ever-changing field of technology has connected like never before, and the use of AVBL to conduct and supplement content delivery in education is rising in popularity. The sudden transformation to online instruction (MCMC, 2021) to curb virus transmission during the COVID-19 pandemic raised critical concerns as a large population has limited electronic devices and unstable internet access (Mondal et al., 2021). Adopting AVBL in remote online classrooms is an alternative to the problem.

Learning is a continuous process, regardless of age; thus, understanding and developing new ideas can be very challenging. To address this matter, AVBL is applied in various fields of education such as cognitive behaviour therapy, physical education, English language, Science and Mathematics, and many more (Bordes et al., 2021; Lapitan et al., 2021; Lee et al., 2021; Mondal et al., 2021; Prasad et al., 2018). These studies are conducted at primary and secondary levels and in higher education. Evidently, the adoption of AVBL can promote a positive learning environment because students feel more involved and responsible for their learning (Lee et al., 2021; Mondal et al., 2021; Prasad et al., 2018).

Its main feature, which allows students to watch the pre-recorded videos when they have access to devices and a stable Internet connection, makes it preferable among learners (Lapitan et al., 2021, Mondal et al., 2021). AVBL also allows students to progress at their own pace (Lapitan et al., 2021;

Mondal et al., 2021), as they can watch the pre-recorded videos at a time and place that is convenient to them. Another issue AVBL address due to unstable internet connectivity is remote online assessment management. It provides a larger time frame for students to have more comprehensive access, especially for learners with limited internet connectivity (Lapitan et al., 2021).

However, students' viewing attitudes can be affected if the content of the pre-recorded videos is dull and uninteresting (Lee et al., 2021). Students might be less motivated and feel disconnected from their instructors because they cannot get instant feedback from the instructor and vice-versa (Lapitan et al., 2021; Mondal et al., 2021; Prasad et al., 2018). Although it is possible to communicate and give feedback asynchronously, it is very challenging to establish student-teacher relationships in courses where face-to-face exposure is limited (Thomas et al., 2021; Lee et al., 2021).

Moreover, it is worth noting that AVBL can be a hassle to its adopters. It requires teachers to transform the old teaching paradigm to new methods in line with the technology (Lapitan et al., 2021). Preparing materials to produce a high-quality video can cost time and money. Teachers must ensure that the content of the pre-recorded videos is well-organised and exciting enough to garner students' engagement (Bordes et al., 2021). Producing a video is not easy, especially if the teacher is technologically challenged. If the teachers fail to develop outstanding AVBL materials for each lesson, it could risk students' understanding and engagement with the targeted content (Bordes et al., 2021, Lin et al., 2019).

This study uses the Unified Theory of Technology Acceptance and Use of Technology (UTAUT) by Venkatesh et al. (2003) because this model can explain 70% of the variance in user intention. Thus, it is the most effective model for analysing technology acceptance. According to UTAUT, Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions are the factors that can influence users' Behavioural Intention to use a system. Another theory that drives this study is the Active Viewing Framework by Dodson et al. (2018) as a method for enhancing students' learning results and engagement in video-based learning.

Treating video as a non-linear medium, active viewing includes interactive, constructive, and active behaviours. The interactive category is based on a socio-constructive understanding of learning and emphasises learning as a socially-driven process. The constructive behaviours category refers to learners constructing their meaning and making connections between concepts. The active behaviours include, but are not limited to, Interactive Behaviours, Constructive Behaviours, Active Behaviours, and Passive Behaviours (Table 1). Meanwhile, passive behaviours are the opposite of these three categories, which involve watching the video without any interaction.

Table 1. *Active and Passive Viewing Attitude (Dodson et al., 2018)*

	Actions
Interactive Behaviours	Communicating with others Cooperating with others Collaborating with others
Constructive Behaviours	Making connections between learning objects Taking notes to record sense making Highlighting video content for future use Tagging video content for future use
Active Behaviours	Browsing for general information Searching for specific information Triaging between learning objects, such as a video and a textbook Re-watching specific video content Pausing video content to reflect on the video content or engage in another viewing behaviour
Passive Behaviours	Playing video content

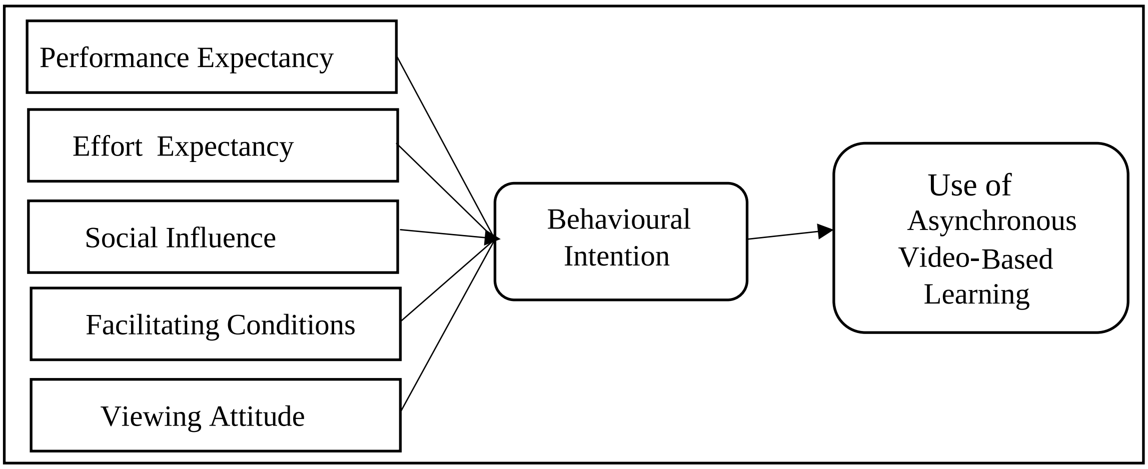

Figure 1. Proposed Active-UTAUT Conceptual Framework

UTAUT and AVF will be able to provide in-depth insights on how videos can be included in a variety of active learning situations to increase student engagement and motivation while also fostering a fun, friendly, and welcoming learning atmosphere.

2. Research Objective

The main research objective of this study is to investigate factors affecting the students' acceptance of AVBL to support their learning. Several research questions have been identified to address the research objective:

i. What is the extent of students' use of AVBL to support their learning?
ii. What are the relationships between performance expectancy, effort expectancy, social influence, viewing attitude, and facilitating conditions and the use of AVBL among students? iii. What is the proportion of variance in students' use of AVBL to support their learning that can be explained by performance expectancy, effort expectancy, social influence, viewing attitude, and facilitating conditions and the significance of each in explaining AVBL use?

3. Research Methodology

3.1 Research Design

The study follows a quantitative research approach with a correlational research design. A survey research design will be employed since it is advantageous given the size of the study's target population (Cresswell, 2014).

3.2 Population, Sample Size and Sampling Technique

It is estimated that there are 1,988,331 registered secondary school students nationwide (Department of Statistics Malaysia Official Portal, 2020). In this study, video is defined as any videos teachers share with their students. Asynchronous learning is when students are required to study the online materials provided by the teachers on their own time within the time stipulated. Thus, this study defined AVBL as online asynchronous learning using related videos provided by the teachers. Based on this premise, this study assumes that every secondary school student in Malaysia has at least one experience of using AVBL (especially during the COVID-19 Movement Control Order). This study proposes to employ the cluster sampling technique. Students will be clustered based on the five main regions in Malaysia, namely, Northern, Southern, Eastern, Central and East Malaysia, to ensure the data collected can represent the secondary school student's population in Malaysia. The researcher will identify two schools from each region using AVBL in their teaching and learning sessions. Table 2 illustrates the number of secondary school students in the five zones of the country, with samples drawn in equal proportional representation. Cochran's (1977) was employed to calculate the study's sample size, and the oversampling procedure (Salkind, 2012) was also used to take account of uncooperative subjects and overcome sampling error.

Table 2. *Clustered Sample Size Distribution Based on Five Main Regions in Malaysia*

Zone	Number of Secondary school students	Number of Samples	Number of Samples (50% added)	Percentage Representation
Central (Kuala Lumpur, Selangor, Putrajaya)	459,716	62	93	23.1
North (Perlis, Kedah, Penang, Perak)	428,172	57	86	21.5
South (Johor, Negeri Sembilan, Malacca)	391,094	53	79	19.7
East Coast (Kelantan, Terengganu, Pahang)	310,680	41	62	15.6
East Malaysia (Sabah, Sarawak, Labuan)	398,669	54	81	20.1
Total	1,988,331	267	401	100

3.3 Data Collection and Analysis

An online structured questionnaire will be used to collect the data for this research. The whole process of data collection is planned to last six weeks, taking into consideration the schools' annual calendar to ensure a smooth data collection process.

Data will be analysed using the SPSS statistical tool. To answer the aforementioned research questions, descriptive and inferential statistical analyses will be carried out. Students' level of AVBL use will be analysed descriptively to understand the extent of their usage, providing a platform for teachers to create a positive learning environment. Then, a Pearson correlation will be conducted to determine the relationship between performance expectancy, effort expectancy, social influence, viewing attitude, facilitating conditions, and the use of AVBL among students. This is specifically intended to assist teachers in producing excellent AVBL materials that will improve students' comprehension. Meanwhile, Multiple Linear Regression will be conducted to determine the proportion of variance in students' use of AVBL to support their learning and to understand the significance of each variable in explaining AVBL use which will aid teachers in developing more successful AVBL lesson plans.

4. Concluding Remarks

This study's primary purpose is to identify the factors affecting the students' acceptance of AVBL to support their learning. Understanding the extent of students' use of AVBL will help teachers create engaging teaching and learning activities to foster a good learning environment that is crucial for students to feel more invested in and in charge of their education. Additionally, by providing teachers with knowledge and guidance on how to create excellent AVBL materials for every session, it will minimise the teachers' burden and reduce the likelihood that the students will not comprehend or be engaged with the provided information. Furthermore, knowing the percentage of the variance in students' use of AVBL to support their learning and the significance of each variable in explaining

AVBL use can give teachers a thorough understanding of how to conduct lessons using AVBL effectively. This is to ensure students are motivated and do not feel distant from their teachers due to the nature of AVBL that prevents students from receiving immediate feedback from their teachers.

In short, students and teachers must swiftly adopt the usage of AVBL to learn because there is no assurance that physical teaching and learning activities will not continue to be disrupted, especially after the disastrous effect of the Covid-19 pandemic interrupting teaching and learning activities around the world. Learning through AVBL cannot be separated from distant online learning since it is crucial to prevent any disruptions to maintain students' learning, particularly with the rapid worldwide technological advancement. Thus, it is essential to understand in more depth the factors affecting students' acceptance of AVBL to provide insight into potential future plans for using AVBL in classrooms.

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PLATER: The Use of Information Technology in Counselor Education

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Abstract: The learning dimension and work values provide the underpinnings of a successful counselor education practicum and internship experience. The 'work values' variable structure varies between dichotomous and multidimensionality. The software PLATER Work Values and Personality Clarification inventory was factor analyzed and the results conducted on n = 605 suggest three factors such as The Learning Readiness Principles, Sense of Community Principles, and Collaborative Principles. Components of the subscales which are Learning, and Ethical Meaning were identified being the major intrinsic values orientation after the factor analysis realignment procedure. This identification may simplify the application of the PLATER as a potential training and development tool in the practicum and internship of the counselor education program.

Keywords: Counselor education practicum, internship, software in counseling, information technology in counselor education

1. Introduction

The Board of Counselor (Malaysia) and the Council for Accreditation of Counseling and Related Educational Programs requires practicum and internship components in an accredited entry level counseling program (Warren et al., 2012). The practicum and internship experiential components prepare the counselor trainees' towards engaging themselves in a real on-site counseling work setting. It is through practicum and internship that the counselor trainees put theory into practice and close the knowing-gap (Marinaş et al., 2018). The optimization of learning in such an environment depicts conditions pertaining to the individual trainee as well as dynamics of the work environment itself. Such optimization of the practicum and internship working conditions may maximize the counselor trainees' counseling process during their period of training. According to Wang and Lee (2019), the accumulation of learning experiences would promote self-efficacy for future employment opportunities.

Nevertheless, underlying these conditions are work values and cognitive learning process duly embedded within the counselor trainees' mind-set themselves. In real life work conditions, Wright (2016) indicated that values aligned, and ethical behaviors were found to be the top driver of well-being in 80% of the best work place in the United Kingdom. It may well reflect the practicum and internship work place with similar conditions may sustain the best performance of the counselor trainees in their work setting. Individuals who have attended practicum or internship training would become significantly more socialized in terms of values and performances compared to those who did not attend (Bashir & Long, 2015). The findings can be further clarified through the current study. The purpose of this study is to factor analyze PLATER Work Values and Personality Clarification inventory and to make an empirical assessment of the dimensionality of the scale items.

2. Literature Review

2.1 Learning Dimension

The ability of counselors to realize emphatic feelings and positive regard over the condition and behavior domain of clients are actually considered as being therapeutic in the helping relationship (Othman Mohamed, 2015a; Warren et al., 2013). Counselor trainees need to be skillful in the core elements of empathy, positive regard, and active attending and listening skills. Such skills provide the fundamentals of the advanced capacity towards the implementation of counseling techniques accordingly within the boundaries of each theoretical counseling approach. This ability to communicate emphatically and commit an interactional deliberation is also a pragmatic approach towards cooperative and collaboration efforts specifically in a counseling interactive environment (Othman Mohamed, 2015a). It is this pragmatic constructivist approach that provides the challenge of the new education phenomenon towards enhancing an innovative and meaningful outcome of the cognitive learning process. Meaning making and creativity which enhances deep learning (Carnes-Holt et al., 2016; Foo et al., 2017; Warren et al., 2012; Zakaria et al., 2020; Zakaria et al., 2022) in the context of self enhancement active learning requires counselor trainees to undergo an active experiential process such as the practicum and internship experience in a real work setting.

In this regard, the new revised Bloom's Taxonomy of Learning Process provided by Anderson and Krothwohl (2001) enlightened a systematic paradigm in an individual's learning process through their learning providers and their self-capacity to excel. The learning process and teaching in the early stages of an individual development occurs through the process of modelling. The cognitive process becomes more prominent during the individual's maturity development (Balich et al., 2015). Anderson and Krothwohl (2001) had envisaged the levels of cognitive process and the knowledge dimension as shown in the learning objectives matrix (see Table 1).

Among counselor trainees, it is the aptitude of implementing what has been learned during the counselor education process and valuing the development of their cognitive ability that may contribute towards achieving an optimum counseling process outcome (Subarimaniam et al., 2020; Zakaria et al., 2017). If during the practicum or internship a counselor trainee has an objective of applying the strategy of brainstorming in a focus group counseling, then the ideal process outcome would be to understand the brainstorming concept in the delivery of ideas. Table 1 shows the ideal learning objectives of the brainstorming technique (Othman Mohamed, 2015a).

Table 1. *The Cognitive Process Dimension*

The Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge						
Conceptual Knowledge		Objective X	Objective X			
Procedural Knowledge			Objective X			
Metacognitive Knowledge			Objective X	Objective X	Objective X	Objective X

Descriptive matrix between the knowledge dimension and the cognitive process dimension of the revised taxonomy of educational objectives.

Source: Othman Mohamed (2015). *The New Education SEAL Self Enhanced Active Learning*. UPM Press.

Subsequently, the brainstorming technique could be applied in context of the group counseling process. Also, invoke a strategy of the brainstorming technique towards generating new ideas towards solving a problem (Othman Mohamed, 2015a). This procedure is reflected as learning objectives marked X in the matrix (See Table 1). The counselor trainees are expected to perform their metacognitive acumen and their ability towards reaching the creative context in addressing solutions by the group counseling clienteles' problem issues.

2.2 Work Values Dimension

The learning process is a component of the values dimension. Values being the core beliefs of an individual may influence active actions translated into behaviour. Values guide actions, attitudes, and judgement (Rokeach, 1973). As values are learned, so are acceptance of ethical meaning evolving in the mind-set of individuals. However, work values are subset of beliefs and ideas closely related with occupational job setting. Work values are often incorporated into employees' development and workplace achievement (Mat Ali & Panatik, 2013). Individuals with positive work values would project positive work behaviours and consequently, high commitment, and satisfaction in the work (Bakar et al., 2011). Furthermore, work values influence how individuals choose their career paths and demonstrate engagement at work (Wong & Yuen, 2012). In this light, the literature dwell upon various descriptive dimensions classifying work values as a dichotomy, trichotomy, four or five dimensional, and multi-dimensional perspectives. Herzberg (1966) favoured the dichotomy of intrinsic and extrinsic nature of work values. It is assumed that intrinsic values are inherent in an activity whereas extrinsic values connote an outcome activity.

Super and Super (1957) maintained the three dimensional intrinsic, extrinsic, and extrinsic rewards categorization categorisations. In this regard, Aldefer (1972) replaced the extrinsic rewards with social value. Subsequently, Ros et al. (1999) introduced the four-dimensional categorization taking into account intrinsic, extrinsic, social, and power as the work values variables. This categorization is within the conceptual boundaries of the new education expectation. Herein, intrinsic values reflect personal growth, autonomy, interest, and creativity (Mat Ali & Panatik, 2013; Wong & Yuen, 2015). Extrinsic values reflect such matters as reward and security (Mat Ali & Panatik, 2013; Wong & Yuen, 2015). Social values reflect common contact with people; and power is a reflective of prestige, authority, and influence. Ros et al. (1999) ascertained that these work values are expression of the general human values in a work setting.

In this regard, the orientation of intrinsic and extrinsic work values are formative perceptions of work goals. The new education related with cognitive-constructivism is more aligned with these definitive descriptions. Vansteenkiste et al. (2007) indicated that workers that are more conscientious are more likely to be motivated and more adapted to intrinsic values. Furthermore, regression analysis studies indicated employees that attached relatively more on extrinsic values were less satisfied with their jobs and less happy with their life (Vansteenkiste et al., 2007).

3. Methodology

The sample of 605 was randomly selected from a pool of 800 candidates who were administered the PLATER Work Values & Personality Clarification inventory (PLATER) as part of a scholarship screening exercise by a business corporation in Malaysia for entry into the Malaysian universities and universities outside Malaysia. The PLATER Work Values & Personality Clarification inventory was developed in the form of a computer software by Othman Mohamed (2015b). Two inventories are embedded in the software: (a) The PLATER Work Values Clarification; and (b) the PLATER Work Personality Clarification. Only the PLATER Work Values Clarification inventory is of interest in this study.

The inventory in its full digital form consists of 72 items which are randomized upon each administration of the software. The items response was administered using a four interval Likert scale: (1) Not Very Important at All; (2) Not Very Important; (3) Important; and (4) Very Important. The randomization of the 72 items ensures the security of a unique set of individualized inventory unit for each user. Six work values variable dimensions such as purpose, learning, aptitude, teamwork, ethical meaning, and relationship (PLATER) with each variable dimension containing six sub items in dual pairs were duly constructed. Figure 1 shows the PLATER Work Values Clarification computer dashboard depicting the six variable dimensions and the six subscales with their respective item scores.

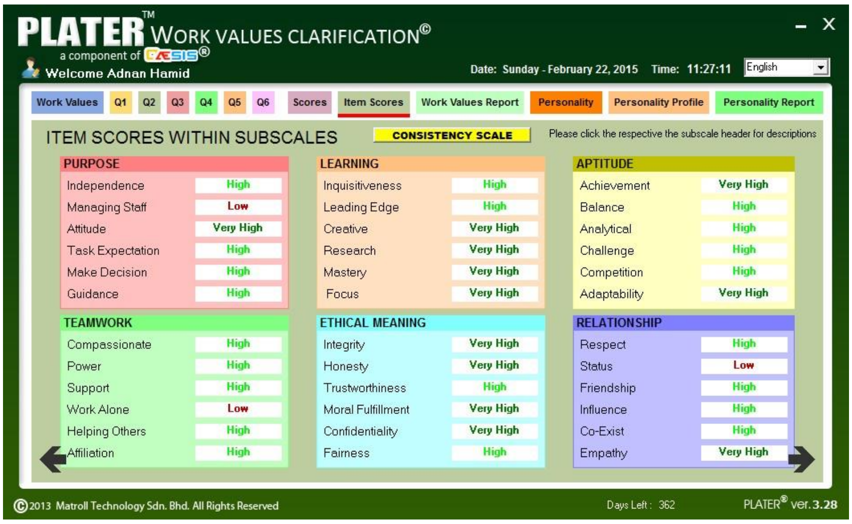

Figure 1. PLATER Work Values Clarification six variable dimensions.

4. Findings

4.1 Factor Analysis

Consideration of a factor analysis ought to meet the requirement of a good sampling fit. The n = 605 in the study met this requirement (Tabachnick & Fidell, 2007). The factor analysis was pursued upon the appropriate results of the Keiser Meyer Olkin (KMO) and the Bartlett Test achieving a significant high level .899 (See Table 2). Costello and Osborne (2005) indicated that a factor analysis can identify the underlying factor structure and analyse any shared variance that is accounted for in the components, thus permitting a more accurate rendition of the factor structure.

Table 2. *KMO and Bartlett's Test*

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.899
Bartlett's Test of Sphericity	Approx. Chi-Square	2364.982
	df	15
	Sig.	.000

Three factors were extracted upon application of the Principle Axis Factoring as shown in Table 3. This procedure detailed the identification of the original six variable dimensions into three common components with the items' commonalities index varying between .620 and .822 which is considered moderate (See Table 3 and Table 4).

Table 3. *Factor Matrix of PLATER Work Values Clarification*

	Factor		
	1	2	3
Purpose	.853		.129
Learning	.763	-.275	
Aptitude	.830	-.218	
Teamwork	.750	.314	.116
Ethical Meaning	.773		-.147
Relationship	.867	.250	

Extraction Method: Principal Axis Factoring.

a. 3 factors extracted. 15 iterations required.

Table 4. *Moderate Communalities of the PLATER Work Values Variables Dimension*

	Initial	Extraction
Purpose	.662	.751
Learning	.558	.660
Aptitude	.637	.738
Teamwork	.549	.674
Ethical Meaning	.556	.620
Relationship	.682	.822

Extraction Method: Principal Axis Factoring.

The alignment of the three factors were achieved through a factor plot rotation, thus permitting a visualized identification of the three factor components (See Figure 2).

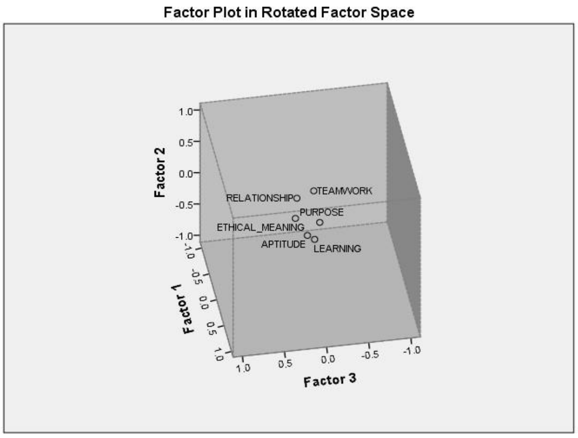

Figure 2. Factor plot in rotated factor space.

Factor One aligned the variable dimensions Learning and Aptitude being defined as Learning Readiness Principles. Factor Two aligned the variable dimensions Ethical Meaning and Purpose being defined as Sense of Community Principles. Subsequently, the variable dimension Teamwork is closely aligned with the variable dimension Relationship, permitting Factor Three being defined as Collaborative Principles (See Figure 3). The three factors' aggregates were realigned accordingly as in Figure 3, taking advantage of the classification of the new dimensions Learning Readiness Principles, Sense of Community Principles, and Collaborative Principles. This procedure would simplify the interpretation of the results of the PLATER Work Values Clarification inventory as a training development tool and its implications for the counseling practicum and internship in a counselor education programme.

In Figure 3, the Intrinsic Values Orientation box clearly contained these two variable dimensions Learning and Ethical meaning with overlapping coverage of variables Aptitude, Purpose, Relationship, and Teamwork. It must be emphasized that intrinsic and extrinsic work values is not in a continuum. They are in fact a reflection of the articulation and need upon a desirable individual's need. Individual orientation of need differs, nevertheless embedded values learned over the years in an individual's lifestyle do impact upon actions, attitudes, and judgement (Rokeach, 1973).

Schwartz and Sarkis (1999) emphasized distinct intrinsic values as interesting work, meaningful work, opportunity for growth, and utilization of ability and knowledge. These are items in the Learning and Ethical Meaning variable dimensions. The PLATER Work Values Clarification inventory variable dimension, Learning comprises six subscales embedded in 12 paired items: being creative, ability to conduct research, mastering of specific skills, being focus, and sensitive on leading edge factors are considered as intrinsic values. Also, the variable dimension Ethical Meaning comprises six subscales embedded in 12 paired items: integrity, honesty, trustworthiness, moral fulfilment, confidentiality, and fairness are indicative of intrinsic values.

4.2 Discussion on Application Implications

The overlapping boundaries of the Intrinsic Values Orientation box into the Aptitude, Purpose, Relationship, and Teamwork is indicative of pertinent intrinsic components in all the three realigned factors (see Figure 3).

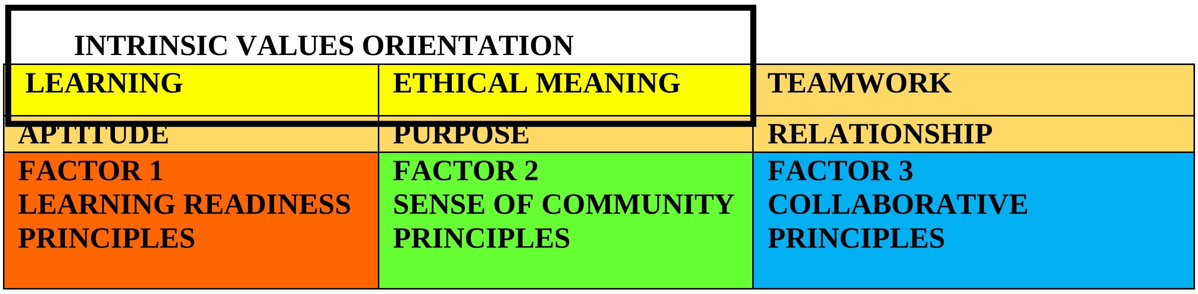

Figure 3. Variable Dimensions of the PLATER Work Values Clarification Alignment with the Three Factors Analysis Components

Part of Aptitude items components such as Achievement, Analytical, and Adaptability may account being intrinsic components. Items components such as Independence, Attitude in the variable dimension Aptitude may also be partial components of intrinsic values. Items components such as Empathy, being Compassionate, and Helping Others in the variable dimension Relationship may also contribute towards intrinsic values orientation (See Figure 3). In the PLATER Work Values Clarification inventory, component items such as Challenge, Competition in the variable dimension Aptitude; Power and Affiliation in the variable dimension Teamwork; Task Expectation in the variable dimension Purpose are assigned as extrinsic values orientations. In the literature, Williams et al. (2000) cautiously indicated that extrinsic values are related with higher emotional exhaustion.

Previous research studies of work values in organizations suggested there is a correlation between positive work values and work-related attitudes (Froese & Xiao, 2012). In this regard, there is an openness to change and interest in growth and creativity in the work setting. It is pertinent to note in view of the Intrinsic Values Orientation realignment of the PLATER Work Values Clarification inventory, the items and subscales of the Learning and Ethical Meaning dimensions to reflect the elements of growth and creativity. Blaunt et al. (2018) and Dillman Taylor et al. (2017) indicated that the cognitive constructivist-based activities may increase competence in content areas. In this regard, the identification of the Learning dimensions as intrinsic values may assist in the training and development of the practicum and internship component in a counselor education programme. Dillman Taylor et al. (2017), McAuliffe and Eriksen (2000); and Young and Hundley (2013) indicated that cognitive-constructivist learning approach postulating a hands-on experiential approach are acknowledged as effective for future practitioners.

Vecchio (1980), Trompenaars (1993), and Huff and Kelly (2004) indicated work values as being important in moulding individuals' specific work expectations and performance role. The subscales in the PLATER Aptitude dimensions do reflect contents related with achievement, analytical, and adaptability. Furthermore, in the work values Purpose dimension, subscales items independence and attitude are all reflective of work-related expectation and performance.

On the other hand, ethics are highlighted in the code of conduct of counselors in training as well as practitioners (ACA, 2014; CACREP, 2016; Warren et al., 2014). There would be multiple ethical challenges in the real counseling work setting (Zakaria, 2007; 2013; Zakaria & Warren, 2014; 2016). Being sensitive and instilling awareness of ethical meanings are important elements in the training of counselors as a preparation for complexities in counseling work (Zakaria, 2007; 2013; Zakaria & Warren, 2014; 2016). In the PLATER realigned factors, the work values dimension Ethical Meaning clearly lies within the Sense of Community Principles underlying its importance within the Intrinsic Values Orientation boundary. Subscale items in the work values Ethical Meaning dimensions reflect contents related with integrity, honesty, trustworthiness, moral fulfilment, confidentiality, and fairness.

These are core issues in ethical considerations that ought to be emphasize in a training and development during the practicum and internship in the counselor education program.

5. Conclusion

Factor analysis of the PLATER Work Values Clarification inventory identified three factors inclusive of Learning Readiness Principles, Sense of Community Principles, and Collaborative Principles. The literature studies on work values have identified structural dimensions varying between the dichotomous and multidimensional dimensions. Under the revised taxonomy of cognitive domain and metacognition as a learning outcome in the knowledge dimension matrix, there is relevance of the self-learning emphasis in counselor practicum and internship exercise. The identification of Intrinsic Values Orientation components shows the potential of the cognitive learning process and work values embedded in the PLATER Work Values Clarification inventory as a training and development tool for the counseling practicum and internship in the counselor education programme.

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From Rejection to Delight: The Change of College Ideological and Political Teachers' Attitude Towards Blended Teaching

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Abstract: This paper takes a case study approach to analyze the changing attitudes of a university's Ideological and Political teachers to blended teaching as a mode of teaching. Data were collected through interview, observation, and material collection methods and studied in a combination of contextual and analogical analysis to classify the stages of attitude change in teaching as passive receivers, struggling pioneers, calm thinkers, and busy sharers. Finally, the causes of attitude change were analyzed in the context of the new institutionalist theory.

Keywords: blended teaching; ideological and political theory course; teaching philosophy

1. Introduction

On June 21, the National Working Conference on Undergraduate Education in the New Era was held at Sichuan University in Chengdu, Sichuan Province, The conference emphasized the need to thoroughly study and implement Xi Jinping's socialist thought of the new era with Chinese characteristics and the spirit of the 19th Party Congress, comprehensively implement the spirit of General Secretary Xi Jinping's important speech at the symposium for teachers and students at Peking University on May 2, adhere to the principle of "based on this" and promote the "four returns", accelerate the construction of high-level undergraduate education, comprehensively improve the ability of talent cultivation, and create a new generation worthy of the great task of national rejuvenation, Moe. (21AD, June 20). The importance of undergraduate education is self-evident. In addition, General Secretary Xi has also made clear on several occasions the shaping and cultivation of socialist core values for youth and used the analogy of "tying the button" as a metaphor, the formation of values in the stage of youth is lie a person tying a button, if it is "wrongly tied" at the beginning, then it will be wrong step by step and eventually go astray. The formation of values in the youth stage is like a person tying a button, if it is "wrongly tied" at the beginning, then it will be wrong step by step and eventually go astray. Thus, undergraduate education is a crucial stage in the formation of young people's values, and the establishment of socialist core values has a clear guiding effect on their development. The current undergraduate ideology and political courses mainly include "Principles of Marxist Philosophy", "Introduction to Deng Xiaoping Theory", "Introduction to Mao Zedong Thought", "Contemporary World Economy and Politics", "Moral and Ethical Cultivation", and "Outline of Modern and Contemporary Chinese History". Nevertheless, some Studies have shown that the teacher as the dominant in the teaching process of ideology and political class, ignoring the major position of students (Lang, T., & Bai, B, 2016). For example, the lack of student interaction in the course, the failure to provide students with opportunities to express their own views, and the inability to create a platform for students to express their personalities. To summarize, the dilemmas of the undergraduate teaching of ideological and political classes can be roughly divided into four categories: (1) the inability of the classes to enter the hearts of students; (2) the overlap between the contents of the teaching materials of the general university classes and those of the middle school classes; (3) the overly theoretical nature of the courses and the lack of practicality; (4) the traditional teaching methods, which cannot fit the psychological characteristics and needs of contemporary college students(Lang, T., & Bai, B). As an important part of higher education, the ideology and political course has the function of educating people and is the main way to carry out systematic ideological and theoretical education for college students (Xie, Huiyuan & Li, Yanting, 2016). How to improve the teaching ability of college ideological and political teachers, enhance the quality of teaching, adapt to the general environment and trend of education development, so as to better play the nurturing goals and functions of the ideological and political course, has become the main task of the college political science course.

According to Singh and Reed (2001) of the American Society for Training and Development, Blended learning focuses on optimizing achievement of learning objectives by applying the “right” learning technologies to match the “right” personal learning style to transfer the “right” skills to the “right” person at the “right” time. Simply put, Blended Learning can be described as a learning program where more than one delivery mode is being used with the objective of optimizing the learning outcome and cost of program delivery. Orey(2002) defines blended learning from the perspective of the learner, the teacher or instructional designer, and the educational administrator, from the learner's perspective "blended learning" is the ability to select equipment, tools, technology, media, and materials that match one's knowledge and learning style to help one achieve learning goals; from the perspective of teachers and instructional designers, "blended learning" refers to the effective organization and distribution of valuable resources (e.g., equipment, tools, technology, media, and materials) to achieve instructional goals; from the perspective of educational administrators, "blended learning" is primarily viewed from the perspective of Cost-effectiveness in organizing and allocating resources to achieve instructional goals. In 2003, Professor He Keqiang (2004), who was then the director of the Teaching Steering Committee of Educational Technology in Higher Education of the Ministry of Education, introduced the concept of blended learning at the 7th Global Chinese Computer Education Application Conference, and since then blended learning has started to spread in China's education field. He believes that blended learning is a combination of the advantages of E-learning (digital learning or online learning) and traditional learning methods, which means that it is necessary to play the leading role of teachers to guide, inspire and monitor the teaching process while fully reflecting the initiative, enthusiasm and creativity of students as the main body of the learning process.

As the main mode of online teaching concept in blended teaching, MOOC has been developing vigorously since the year of 2012, and many top universities in China have joined the ranks of offering MOOC. In terms of cooperative MOOC, Tsinghua University, Peking University, Fudan University and Shanghai Jiaotong University have joined edX and Coursera to align with international high-level MOOCs and learn its concept and model of blended teaching; in terms of independent MOOCs, China has also launched "Xue Tang Online", "Good University Online", "Good University Online", "Good University Online" and "Good University Online". In terms of independent MOOC, China has launched a series of MOOC platforms such as "Xue Tang Online", "Good University Online", "Netease Cloud Class", "Netease Open Class", "China University MOOC", etc. A series of Mooc platforms have been launched in China. In the context of the promotion of blended teaching and MOOC, universities have also tried to combine ideological and political courses with MOOC. Gao Guoxi and Chen Dawen(2015) of Fudan University have developed a MOOC on ideology, moral and legal foundations through the "Wisdom Tree" platform, focusing on students' development and cultivating intrinsic needs, and improving teaching methods. Since 2016, Central South University has been carrying out a blended teaching reform for the Outline of Modern and Contemporary Chinese History course based on the "China University MOOC" platform. The online teaching module includes the course resources and online Q&A, while the face-to-face classroom module includes the important and difficult points, special lectures and student keynote speeches (Weng He Kai & Li Luo,2016). As a key course to implement the fundamental task of educating people with moral values, the importance of the ideology and politics course is self-evident. How to combine the ideas of blended teaching with ideology and politics courses in higher education? How can ideology and politics courses cope with the educational changes brought by blended teaching so that they can become the "golden courses" in universities? Based on this, this study attempts to investigate how the attitude of higher education ideology and politics teachers towards blended teaching has changed.

2. Research Design

2.1Research Methodology and Sources

This study adopts a case study approach, and in accordance with the principles of purpose and convenience, a teacher W, who is a teacher in an ideological and political course- the Outline of Modern and Contemporary Chinese History at a university, was selected as the research study. The reasons include firstly, Mr. W has been carrying out blended teaching reform for the course he has undertaken since 2014, and the teaching concept, teaching materials and teaching mode have been constantly updated and iterated for many years and have been more fixed and shaped. Secondly, Mr. W also researched and thought about the blended teaching model while undertaking the teaching materials of the course and published two relevant papers. We believe that Mr. W has a deeper understanding of the concept of blended teaching and a deeper accumulation of knowledge, which is more conducive to the development of the study. Finally, Mr. W was willing to participate in the study and share his experience to facilitate the smooth conduct of the study.

This study used the interview method, observation method, and material collection method to collect research data. The two formal interviews included a 50-minute formal interview, a 90-minute in-class observation, a complete MOOC courseware of the course, and two papers written by the subjects related to the course philosophy, which are shown in Table 1. The accompanying observation and the MOOC courseware were used to understand the application of teacher W's teaching concept, and teacher W's paper was helpful for us to have a deeper understanding of teacher W's teaching concept.

Table 1: *Data collection*

TYPE	NO	COLLECTION DATE
OBSERVATIONVRECORDS	O-20190318	20190318
MOOC COURSEWARE	A-20190318	20190318
INFORMAL INTERVIEWS	I-20190318	20190318
FORMAL INTERVIEWS	I-20190320	20190320
PAPERS WRITTEN BY MR. W	P-20190321	20190321
	P-20190322	20190322

2.2 Information analysis

A combination of contextual and class analysis was used to conduct this study on the data. From the perspective of contextual analysis, this study presents a timeline of the attitudes and related behaviors of the subjects when offering blended learning courses. In late 2014, Mr. W was "given the task" of recording the MOOC "involuntarily" and "reluctantly". As a "young" (as opposed to senior), "associate" (as opposed to full professor) faculty member who had not studied abroad (as opposed to L's visit to Stanford), W "passively" took on this assignment.

In 2015, Ms. W. began to participate in the recording of MOOC lessons and the experiment of blended teaching. The organizer of the MOOC (Xue Tang Online Inc.) provided relatively sufficient funding for the recording of each lesson, which was higher than the average at this stage. As the organizer and recorder of the MOOC, Xue Tang Online can provide professional technical support, but not historical knowledge. In addition, Mr. W is "a little bit more particular" and requires that the pictures in the MOOC match the actual era. For example, "If the material uses Chairman Mao's speech in 1938, I want you to match the closest picture of Mao in 1938. If there is a photo of Mao Zedong making the speech in the original scene is better, no, then find the closest 1938 Mao Zedong photos. But the director started to put a photo of Chairman Mao after the founding of the country, and it was not right at first glance, which I could not tolerate as a history veteran." As the director of the course, Mr. W would make individual changes to each of such problems, which undoubtedly consumed a lot of Mr. W's time and energy. In 2015, Mr. W pounced all his energy on the application of blended teaching physically nearly dragged down, and 2015 was also the only year when Mr. W did not publish a single academic paper. In addition, because the first year of the MOOC was a side-by-side online format, it was also the richest year for blended learning content. W tried to provide various forms of content but was not able to fully take on the full blended learning vision. "It was a half-blended year," with offline lecture content but not compulsory. "That year the MOOC was the focus" with 7 small group discussions (only 4 since) and 3 master lectures (only one in 2016 and 2017, none in 2018, and still under consideration for 2019) but all optional and non-compulsory. After completing the 2015 course, Mr. W. felt "sorry for the students who took the course" because they learned the basics, "the MOOC should be taught according to the school, for our university students, only the MOOC, the students will 'not eat enough '." In the 2016 and 2017 courses, Mr. W adjusted the lecture mode. The ratio of compulsory offline content to online content is 6:4. The content of the course "has not changed much", except that the number of small group discussions and master lectures has been reduced to 4 and 1 respectively. With the previous attempts to teach, Mr. W also said that his personal experience is getting richer and richer, and he is able to handle it with ease. At the same time, the service level and management level of the Xue Tang Online company continued to improve, and the background data became more diversified, which also provided support and guarantee for Mr. W. The success of the course is not in vain, and in 2017 the course was also selected by the nation as a national quality course.

In 2018, Mr. W improved the content of the course by eliminating the lectures by master teachers and replacing them with more informative small group discussions and offline lectures. 2018 was also the first year that the course started to use "Rain Classroom", a teaching aid, without any group training before using it. The person who is in charge of the classroom has visited Mr. W's office several times to mobilize the use. "The best way to learn is to learn by using", and it is not difficult to learn without systematic training. "Rain Classroom" can assist teachers to sign in and also test students' attention. Through W's exploration and experimentation, Rain Classroom was first tried in our small classrooms in spring 2018 and was also used in large classrooms at other universities in the autumn. The difference between small classrooms and large classrooms is the core bottom line. For large classrooms, it is difficult to know whether students are present without Rain Classroom to assist with check-in. The small classroom does not need to set attendance scores, so "a quick glance will probably tell you who is here and who is not".Mr. W will also check the students' attendance status based on the question-and-answer module. In one of the classes we observed, the class scored an average of 1.4 on the accompanying questions, while in another class with similar content, the average score was only 0.3. Although there was some variability in the content of the questions, the huge gap in mean scores pushed Mr. W to consider how to balance the content of the accompanying questions and the evaluation criteria. As W gained more experience, he began to reflect on blended learning as a teaching model. When participating in teaching seminars and attending lectures invited by other universities, Mr. W also uses blended teaching. Regarding the proportion of blended teaching in different schools, Mr. W thinks that if the proportion of our school is 60% offline, local universities "should not be less than 20 to 30, at least one third".

For the future trend of this course, Mr. W said how to proceed, how much the proportion of mixed or resource-related, after all, blended teaching itself is a high-cost, luxury type of course. When the number of teaching assistants is no longer more than 20 (7-8 from the college, 15 from the Xue Tang online company), "I will not engage in blended teaching", traditional teaching is better "handle". For the form of teaching, Mr. W believes that there is still a need to diversify, "there is no need for a one-size-fits-all, or to diversify, other professors of the course as popular." Theoretically speaking, as long as the resources are sufficient, the more fully mixed ratio the better ideology class, each school should combine their own characteristics, their own faculty resources, the characteristics of the teacher, arrange a different proportion of mixed. "Blended teaching must be appropriate for the school, depending on the teacher." By considering the trend, despite the previous statement of "not rejecting", Mr. W is also vaguely "complaining": after the start of blended teaching, his own teaching assessment score is down. "I used to be number one in the faculty," said W. Because there are more teaching parts, students' dissatisfaction with any of them will be reflected in the faculty assessment. "It used to be about managing yourself, but now it's about managing a TEAM of 20 people." "So blended teaching actually he is still a relatively emerging, in the exploration of things, he is a more extravagant, one to use more educational resources of such a new thing."

From the perspective of category analysis, we coded the interview data. Where GT represents the teacher, and the serial number represents the teacher's discourse tertiary coding.

Table2 Interview Coding

Level 3 Code	Level 2 Code	Level 1 Code
Mr. W's teaching philosophy.	Support for blended learning. Oppose purely online teaching	(GT1) 100% online courses are not compliant (GT1) Do not reject new things (GT5) Traditional teaching and blended teaching cannot be evaluated by one standard (GT7) Do not know much about certain detailed features of rain classroom (GT12) Have not participated in relevant training, hands-on is the main focus (GT28) Prepare seriously for MOOC (GT39) Turn off bulletin to prevent flattery (GT42) Small group discussion offline cannot guarantee quality (45) Relying only on online is not possible (GT53)
Mr. W is a passive recipient and struggling pioneer of blended teaching tasks.	Initial difficulties. High cost of blended learning. youth as the main reason for blended teaching	No mind to deal with blended teaching in 2015 (GT2) Passive to carry out blended teaching (GT3) Named as a national quality course (GT4) When operating PPT, students point not to understand is invisible (GT6) More experience with blended teaching (GT11) Many parts of blended teaching, affecting the assessment score (GT16) Blended teaching is a luxury (GT18) During the preparation of blended teaching It is very tiring (GT20) Teachers are not involved in post-production of MOOC (GT21) Energy is all on line (GT22) Course preparation is intense, teaching while filming, only two classes available (GT24) Old professors are not willing to participate (GT26) Commercial operation of MOOC (GT29) The cost of MOOC production is high at the beginning (GT30) The cost of MOOC production is decreasing year after year (GT31) MOOC production is easy (GT32) Content is much easier than traditional classroom (GT33) Young faculty and associate professors are doing it (GT34) Youth is the main reason to carry out blended teaching (GT35) Started to try Rain Classroom since last year (GT38) Liberal arts courses are relatively easy, students ask less questions with Rain Classroom (GT43) Small classes are familiar with students (GT46) Didn't do other work for a year (GT48) Affected research Output (GT49) Affected my body (GT50) Getting more experienced (GT51) High cost of producing early MOOC (GT52)
Mr. W's attitude towards the implementation of blended teaching。	Conscientiousness. Teaching from teacher to teacher.	Repeatedly prepare their own line scripts (GT13) Implementation process of blended teaching (GT14) Blended teaching to supervise student sign-in (GT17) Can understand students' difficulties (GT23) Won't go through data in class (GT25) All give full marks online and closed-book exams offline (GT36) Unification of ideology and politics with history and science (GT40) Learning analysis through data (GT41) Favorite roll-call function (GT44)

Mr. W's reflections on the process of implementing blended teaching.	Insufficient difficulty. High number of teaching assistants. High strength of technical services	Sorry for the students who took the course in 2015, the course content is not deep enough (GT10) Blended teaching requires a lot of student autonomy (GT19) There are as many teaching assistants assigned to large classes and small classes (GT8) Support from schools with a lot of teaching assistants (GT9) Blended teaching consumes more educational resources (GT15) Without more than twenty teaching assistants, blended teaching cannot continue (GT27) 60% is needed offline in our school and no less than 30% offline in other schools (GT37) The service level of the XUETANG online company has improved (GT47) Teaching assistants have increased and are not as tired (GT54)

3. Change of teachers' attitude towards blended teaching mode

Stage 1: Passive recipient
The initial phase of Mr. W's blended teaching implementation can be described as initially difficult. First, the high cost of blended teaching, and second, the task nature of the blended teaching reform itself, rather than the spontaneous behavior of the teacher. The exogenous nature of motivation led Mr. W to attribute her implementation of blended learning to her age, i.e., "I am asked to do it" rather than "I am going to do it". The lack of internal motivation required stronger external incentives, and the external support that W received during the implementation process was strong, especially at the technical and managerial levels, which was alarming. The scale of 20 teaching assistants for one course was beyond the average teacher's perception, and the shift from a single-team to a team-based approach represented a strong external force that wanted to make the implementation of blended teaching a success.

Stage 2: Struggling pioneers
Mr. W faced a lot of internal struggles and entanglements while implementing the blended teaching reform. Through the analysis of the data, we found that Mr. W experienced "no initiative" and "reluctantly" to "completely devoted to that, very tired". "The only year, there was not a single paper" to "not rejecting blended teaching" to "so blended teaching is still a relatively new and exploring thing, it is a relatively extravagant, a It is a new thing that requires more educational resources". The teaching experience goes through five stages: acceptance, devotion, implementation, management, and reflection, and is characterized by external forces and great teacher input. According to the opportunity cost theory, individuals give up the opportunity to engage in one activity and give up another activity or give up another kind of income when they use certain resources to obtain a certain kind of income. After Mr. W chose the blended teaching model, it means that he gave up using his original time and energy to publish academic papers (not doing other work for a year GT48 , affecting research output GT49 , tired during the preparation of blended teaching GT20), exercise (tired during the preparation of blended teaching GT20 , affecting his body GT50), traditional teaching methods (100% online courses are not eligible GT1, do not reject new things GT5, traditional teaching and blended teaching cannot be evaluated across the board GT7), part of the teaching quality (offline small group discussion cannot guarantee quality GT45 relying only on online is not possible GT53), high satisfaction rating of students before teaching (blended teaching sessions are many, which affects the evaluation score GT16). Despite the seriousness of teachers' teaching attitudes, students' learning results are often unsatisfactory. During the interview, Mr. W said straightforwardly that the course content difficulty could not meet the students' requirements well and felt sorry for them.

Stage 3: The Calm Thinker
In addition to the teachers themselves to the cost of the implementation of mixed teachers in the process, the implementation of the school also bears a lot of costs. (Blended teaching is a luxury GT18, teachers are not involved in the late MOOC production GT21, as many teaching assistants as are assigned to large classes and small classes GT8, get support from schools with

many teaching assistants GT9, blended teaching uses more educational resources GT15, without 20 or so teaching assistants, blended teaching cannot continue GT27, offline needs 60%, other schools offline no less than (30% GT37). Compared with the cost of individuals and schools, the benefits are mainly in terms of student learning outcomes. After the blended teaching reform, students' learning autonomy is required to be higher (blended teaching requires strong student autonomy GT19), and the teaching materials are also required to be more suited to students, otherwise students will react to not having enough to eat. (Sorry for the 2015 students, the course content is not deep enough GT10). For the teachers, the benefits are mainly focused on the courses taught being rated as national quality courses (GT4), and some software applications provide help for teaching when teaching offline. (Learning analysis through data GT41, like the function of roll call GT44)

At the beginning of the implementation of blended teaching, according to the interview results, it is easy to find that to some extent, the costs are more than the benefits. The benefits were relatively disproportionate compared to the input of the school, the college, the online office, and the teachers in it. The college and the online office staffed Mr. W with as many as 20 teaching assistants for the course, which was a relatively high drain on teaching resources. According to marginal cost theory, the incremental amount of total cost per unit of new product produced (or purchased). Although the cost of building a course is currently high, it has dropped from over RMB 200,000 at the beginning to tens of thousands of dollars a course currently. In addition, the cost for faculty to implement a blended course has been decreasing as the corresponding support facilities for blended teaching have been gradually improved. Besides explicit costs, hidden costs such as student acceptance and instructor proficiency will also slowly decrease. According to the marginal cost curve, as a new thing in higher education classroom teaching, the costs and benefits will gradually reach a balance in the long run.

Stage 4: Busy sharer

During the interview, Mr. W received a phone call (after a long ringing time), and the caller was inviting Mr. W to make a presentation for an academic conference as an expert in blended teaching implementation. Mr. W's reply was quite interesting: he was really too busy and sorry that he could not attend, but he could organize the text materials and PPTs and send them to the conference organizer. According to the information obtained by us, there are many similar communication and sharing activities for Mr. W. As a pioneer of hybrid teaching reform, many universities and academic communities invite Mr. W. to share his experience.

4. Conclusion and Discussion

New institutionalism emerged in the 1970s and 1980s as a powerful critique of the old institutionalism and behaviorism, and since the 1990s it has been adopted and applied as an interdisciplinary trend in disciplines such as political science, economics, and sociology. In particular, new institutionalism emphasizes that the behavior of individuals in organizations and institutions is strongly influenced and conditioned by the institutional environment and organizational field. New institutionalism includes formal institutions such as laws, rules, rewards, and punishments as well as informal institutions such as proof of eligibility, recognition of qualifications, and shared beliefs. New institutionalism believes that institutions have the value function of shaping human behavior, and that individual or collective human behavior is conditioned to varying degrees by the external institutional environment (Zhao Min,2018).

Teaching concept and teaching culture are the indispensable components of the teaching system of universities. Firstly, teaching concept is formed by historical tradition, custom, educational experience and knowledge accumulation; secondly, teaching culture is constructed by emotional awareness, practical reflection, rational design and systematic rules, which is the behavior pattern and teaching standard formed in the long-term teaching practice. The cultural system of teaching system can regulate the behavior and mutual relationship among teaching subjects (Zhao, Zhe & Yang, Yi-Fei,2016). In this study, we analyzed the teaching philosophy of the first group of teachers who implemented blended teaching at a university, and Mr. W experienced the process of emergence, implementation, and reflection. As one of the first to take part in the "higher education teaching reform", Mr. W's individual teaching experience also reflects to some extent the development of higher education in China.

Online MOOC, rainy classroom, and collaborative learning led by teaching assistants are some of the key words of blended teaching. What Mr. W practiced was not only the mix of online and offline, but also the mix of resources and activities. The development of Internet brings continuous innovation and changes in teaching mode, and information technology plays an increasingly important role in the reform of teaching mode of college courses. Through the dialogue with literature, we can understand that the blended teaching mode based on MOOC has the characteristics of convenience, personalization, interactivity, sharing and openness. Many students' learning interests and subjective motivation are also stimulated, however, as the first batch of college teachers implementing the blended teaching reform, doubts still occupy a large part in the face of a bewildering blue ocean of college teaching.

New institutionalism argues that only when the expected benefits of institutional innovation are greater than the expected costs do innovative agents have the will or incentive to supply institutions (Liu Yi, 2017). Teaching reform in higher education is a special form of institutional reform, and the subjects of teaching reform in higher education, including but not limited to teaching administrators, teachers and students, all consider the benefits of institutional innovation for themselves. As analyzed earlier, Mr. W paid a lot of individual costs upfront, including time, energy, health, and research, etc., in order to implement blended teaching, and the school, college, and online office also paid a lot of costs. However, from the perspective of the future, these upfront costs will certainly gradually decline, so that in the future there will be more teachers with the appropriate information technology teaching concept, for this part of the teacher, only a small cost to implement a complete blended teaching. Mr. Lu Xun once praised the so-called first crab eaters, "admirable" and "warriors". For the "crab" thing, the first to eat certainly bear certain risks and costs, but the benefits are also more lucrative in comparison. For example, they can introduce the "crab eating experience", "which part of the crab can be eaten and which part is delicious" We also know from the interviews that early implementers of blended teaching receive strong support from external stakeholders, while this support tends to be much weaker in later years. While eating the crab, the pioneers may have had their fingers pricked by the crab pincers or been wrapped up in a great sense of isolation. The pioneers of blended teaching are constantly playing with themselves in order to reach a better state between input and output. Mr. W, who has completed the "0 to 1" process of blended teaching, and other outstanding teachers will complete the rest of the "1 to 10" process. The pioneers and the followers are not a zero-sum game, but a win-win model.

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Health Anxiety, Information Anxiety, and Internet Self-Efficacy on Cyberchondria among Filipino Young Professionals during the COVID-19 Pandemic

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Abstract: The mobility restrictions due to COVID-19 lockdown impositions have forced people to stay at home in lieu of face-to-face activities. In effect, it has increased people's exposure to the Internet and its perils, brought by excessive information from different media that may lead to the development of health-related anxiety. This phenomenon is known as cyberchondria, where people may have experienced extreme anxiety about their physical health because of repeated internet searches concerning their medical conditions. This paper investigates the possible relationship between health anxiety, information anxiety, and computer self-efficacy toward cyberchondria. Data from a cross-sectional method using online surveys among fresh graduates aged 21-24 in several Philippine higher education institutions were analyzed. The results of the structural model test reveal that both health anxiety and information anxiety may contribute to cyberchondria. The study discusses the implication of the results and offers fruitful research directions for further studies.

Keywords: Cyberchondria, Internet Self-Efficacy, Health Anxiety, Information Anxiety

1. Introduction

Recent advances on the Internet and other digital technologies have transformed almost all aspects of our lives, spanning our education, work, and social life. The Internet and other digital technologies have been recognized as enabling tools for learning and educational use as it expands access to the wealth of information. With the ongoing onset of the COVID-19 pandemic, these technologies created new pedagogical possibilities and enabled innovative services of Internet platforms that accelerated the spread of online learning for professional development and lifelong learning. However, despite the benefits of the Internet and digital technologies, the changing social environment, the emerging learning circumstances, and the appropriation of the right technology often create challenges that the academic community and industry practitioners cannot ignore. During the pandemic, when various communities hurdle physical restrictions, the Internet remained the only sound information source for many people to answer questions about health when accessing health professionals became more difficult. Indeed, in the early stages of the COVID- 19 outbreak, the Internet became an essential channel for vital public health and safety information. However, by increasing Internet exposure considering its potential uncertainty and risk, the pandemic is likely to have exposed vulnerable individuals to the risk of developing health-related anxiety (Vismara et al., 2021).

Although Internet-based health information can enable underserved individuals to make informed health decisions about their health (Zheng et al., 2021), the excessive information from all types of media has also exacerbated several psychological effects, such as the surge of individuals dealing with health anxiety, medical concerns, and stresses (Ambrosini et al., 2022). The rise of these health-related psychological stresses during a pandemic encourages individuals to seek self-diagnosis and general knowledge about COVID-19 and other diseases (Shan et al., 2022). Past studies argue that the self-diagnosis behavior of individuals invites unnecessary psychological stress, mainly attributed to the possible exaggeration of fears about their health conditions. The proliferation of medical information online raises the possibility of finding information that is misleading, unreliable, and susceptible to misinterpretation resulting in escalation of anxiety (Gass, 2016). This phenomenon, as coined by White and Horvitz (2002), is known in cyberpsychology as cyberchondria which is the excessive and repetitive utilization of Internet resources for information on the individual's health, leading to heightened paranoia. Cyberchondria is a relatively emerging issue, but with the advancement of high-speed Internet and mobile phones, it has become a public health issue in developing economies (Menon et al., 2020), especially during the COVID-19 pandemic. Susceptibility to cyberchondria varies, and a prior study established a linkage between the increased availability of information on the Internet and the influence of health anxiety (Padagas et al., 2022).

During the onset of the COVID-19 pandemic, higher rates of anxiety and depression and risk of cyberchondria are reported among young professionals compared to their older counterparts (Korkmaz et al., 2022; Jackson et al., 2020). Sources of this anxiety and depression vary from early career employment to health issues. The Internet has become a constant resource in addressing these health issues, which may heighten cyberchondria (Erdogan et al., 2022). In this paper, the authors propose to investigate the relationship between the psychological factors of health anxiety, information anxiety, and internet self-efficacy on cyberchondria in the context of young professionals who recently graduated from higher education in a developing economy. As young professionals contribute primarily to the economic development of a developing country, a more profound understanding of the relationship between psychological factors and escalations of internet anxiety among young professionals will be beneficial to continuing educational institutions, workplaces, and regulatory bodies, to support their development and well-being.

2. Related Literature

The pandemic heightened health anxiety, where massive information from different media about COVID-19 escalated concerns and distress across the general population (Jokic-Begic et al., 2020). Jungmann and Witthöft (2020) argued that based on cognitive-behavioral models, triggering events play a critical role in the emergence and maintenance of health anxiety. With this ongoing coronavirus pandemic, health anxiety can be a severe psychological issue, amplified by social isolation and health-related information uncertainty (Maftei & Holman, 2020). Health anxiety is when a person has unwarranted or excessive concerns about their health circumstances (Korkmaz et al., 2022). Prior studies argue that people with pre-existing health anxiety tendencies are vulnerable to escalated anxiety and other adverse behaviors during a pandemic (Jungmann & Witthöft, 2020; Starcevic et al., 2020; Zheng et al., 2021). While recent literature linking cyberchondria as a pattern of excessive and repetitive internet self-diagnosis behavior is claimed to be related to underlying health anxiety (Dohert-Torstrick et al., 2016); this concept is not yet investigated with young professionals in an emerging economy. As such, we hypothesize that:

H1: Health anxiety positively influences cyberchondria

During the COVID-19 pandemic outbreak, a tremendous amount of information is increasingly available in digital information sources and overwhelms any individual who is typified by their inability to access, understand, organize, or make use of information in any setting at their disposal (Ojo, 2016; Skarpa & Garoufallou, 2021). The proliferation of health-related information and websites is driven by the desire of individuals to have an initial understanding of their health concerns (Akhtar & Fatima, 2020). However, numerous studies suggest excessive exposure and interaction with online medical content may intensify anxiety (White & Horvitz, 2012). Prior studies argue that extreme information uncertainty is a major cause of information anxiety (Girard & Allison, 2015). The stress induced by the health-related searches online may lead to uncontrolled risky behavior leading to cyberchondria (Aiken & Kirwan, 2012), especially among young professionals who are viewed as active seekers and users of online health information (Rains, 2014). The study of Baumgartner and Hartmann (2011) explored the relationship between health anxiety and online search behavior, revealing that anxious individuals experience negative consequences from using the Internet for searching for health information. As a result, we hypothesize that:

H2: Information Anxiety positively influences cyberchondria

Online health learning has transformed and evolved over the years and has been greatly influenced by advances in the Internet and digital technologies coupled with the increasing knowledge and skills to be learned and acquired by individuals (Markowitz & Reid, 2018). With younger professionals, known to be digital natives who have been born into environments in which Internet technology is used regularly (Chuang, Lin, & Tsai, 2015; Grzeslo, 2020), it is also observed that they are frequent users of electronic health resources and online communities for their health issues (Schneider et al., 2018). Despite coming of age in an increasingly digitized society, these young professionals, with their view of technology as a new social environment, have experienced more anxiety and depression than their older counterparts (Dalessandro, 2018; Korkmaz et al., 2022; Varma et al., 2020). With the outbreak of COVID-19 and the adoption of work-from-home arrangements and online learning, the Internet as an informational channel may exert unique affective pressure on those with health anxiety (Dohert-Torstrick et al., 2016). Thus, we hypothesize that:

H3: Internet Self-Efficacy positively influences cyberchondria

In the context of this study, we hypothesize that Health Anxiety, Information Anxiety, and Internet Self-efficacy are psychological factors towards cyberchondria, as depicted in Figure 1 – Theoretical Framework.

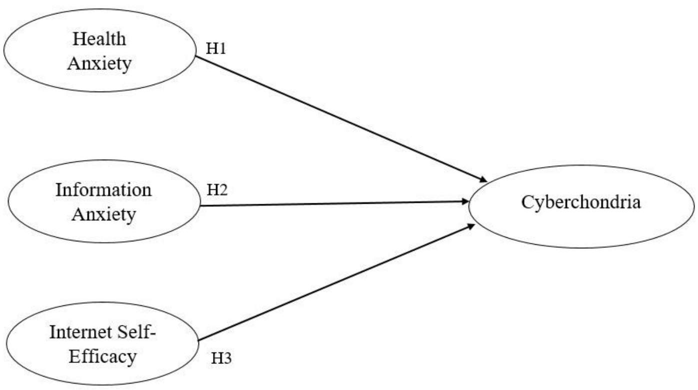

Figure 1. Theoretical Framework

3. Methodology

Using an online survey, the study used a cross-sectional method to investigate the relationship between psychological factors and cyberchondria. Fresh graduates aged 21-24 years old from several Philippine higher education institutions were invited to participate in an online survey. As the new entrants to the labor market during the COVID-19 pandemic, the career perspective of these young people remains uncertain and fragile, which brings worries and tension to their psychological well-being (Petruzziello et al., 2022). The aim of this study, its sections, and privacy protocols were explicitly stated at the start of the survey. One hundred ninety-one responses were recorded and analyzed for construct validation and hypothesis testing. Item questionnaire for each variable of the theoretical framework was adapted from past literature. There are twenty-one (21) questions from the health anxiety study of Lucock and Morley (1996), five (5) questions on information anxiety (Girard & Allison, 2015), and ten (10) items for internet self-efficacy (Suana, Riyanda, & Putri, 2019).

On the other hand, the questions to represent cyberchondria were taken from McElroy and Shevlin (2013). The cyberchondria instrument consists of thirty-three (33) items about an individual's perceptions of the Internet's health information, their practices with the use of the Internet to search for health-related information, and how the Internet influences their health concerns. Participants answered using a five-point Likert scale ranging from 1 – "Never" to 5 - "Always". The majority of the respondents are fresh female graduates aged 21-24, accounting for 58% or 110 of those who participated in the study. The rest are fresh male graduates, with a total of 81 or 42% of the total recorded responses.

Considering the research locale and adaptation of items from different disciplines, testing for reliability and convergent validity is essential to establish instrument precision. A pilot test was conducted online with fifty (50) participants, and responses were analyzed using SmartPLS. Using a Partial Least Square or PLS algorithm, this study extracted the Cronbach Alpha and Composite Reliability for reliability and Average Variance Extracted or AVE for convergent validity. This process was repeated in several iterations after removing items until values of 0.70 for reliability and 0.50 for convergent validity were above the minimum values (Henseler et al., 2014; Nelson et al., 2016). After the pilot test, 52 items were retained in the final structural model.

4. Results and Discussion

We applied a bootstrapping technique to our dataset to test our hypotheses using the latest version of SmartPLS (Ringle, Wende, & Becker, 2015). As shown in Table 3, the coefficient values for H1, H2, and H3 are 0.411, 0.342, and 0.125, respectively. While these values indicate positive relationships between health anxiety, information anxiety, and Internet self-efficacy to cyberchondria, the t- values of 0.192 for H3 suggest that the relationship is insignificant. On the other hand, the t- values of 3.582 for the relationship between health anxiety to cyberchondria and 3.298 for the relationship between Internet self-efficacy and cyberchondria are significant, given that the values are above the minimum value of 1.96 (Hair, Hult, Ringle, & Sarstedt, 2014).

Table 1. Results

Hypothesis	Coefficient	*t* - value	*p*-value	Decision
H1: Health Anxiety → Cyberchondria	0.411	3.923	0.000	Supported
H2: Information Anxiety → Cyberchondria	0.342	3.340	0.001	Supported
H3: Internet Self-Efficacy → Cyberchondria	0.125	1.296	0.196	Not Supported

The results of the structural model test reveal that both health anxiety (H1) and information anxiety (H2) lead to cyberchondria. The findings are consistent with recent studies that attribute both factors as positive determinants of cyberchondria (Nadeem et al., 2022; Qiao et al., 2021; Yang et al., 2022). The statistical results can be interpreted within the bounds of prevailing conditions in the Philippines and its related socio-cultural context. While society has slowly transitioned toward living with COVID-19, studies argue that its long-term impact on social processes will influence how people live in the coming years (Carter et al., 2021). As a result, the general population, including young professionals, experienced a higher level of health anxiety during the pandemic due to the death or sickness of people in their social networks (Haig-Ferguson et al., 2021). This health anxiety will result in individuals constantly looking for medical information online that will provide comfort and satisfy their curiosity if there is no access to medical expertise. This information overload results in information anxiety, when individuals are overwhelmed with a wealth of information beyond what their cognitive faculties can process.

The pandemic restrictions encouraged workers to perform their job functions at home, and it has been observed that Internet access reached unprecedented levels. While a body of information systems research highlighted the various benefits of working from the comforts of home, studies also suggest problematic Internet use resulting from an online work environment during COVID-19 (Islam et al., 2020). In addition, the inadequate services of the Philippine healthcare system and exposure to misinformation online and on social media encouraged Filipinos to seek medical information online, which may lead to cyberchondria (Oducado et al., 2021; Superio et al., 2021). Therefore, it is common for young professionals working from home to experience anxiety brought about by health (H1) and information consumption of medical information (H2). Due to the availability of technology and access to the Internet, they look for medical information online as compensatory behavior to address their current psychological state.

Strides in educational reforms to integrate technology into the curricula of universities equipped young Filipino professionals to join the workforce with the necessary skills to search for relevant information to satisfy their cognitive needs. A possible reason why our study contradicts the work of Suana et al. (2019) is that the same Internet technology skills (H3) of our respondents were used to seek medical information from medical experts online (Yoo, Li, & Xu, 2021). Another explanation is that the Department of Health and other health regulatory bodies in the Philippines utilized social media to disseminate quickly developing information in the fight against COVID-19 (Galido et al., 2021). In addition to their skills to seek credible and accurate information, social media networks such as Facebook and Twitter launched fact-checking features to control the spread of misinformation about COVID-19. As digital natives and social media users, young professionals rely on these platforms to get relevant information about the pandemic (Vitelar, 2019).

5. Conclusion, Limitations, and Recommendations

To conclude, cyberchondria is an ongoing concern exacerbated by the lack of health literacy, psychological factors, and the convenience of access to online health information. The results of our empirical study confirmed that health anxiety and information anxiety are antecedents of cyberchondria. On the other hand, statistical results do not support that Internet self-efficacy positively influences cyberchondria. Our findings should be construed within the confines of our methodological constraints. First, while our study sample is small, future research can be undertaken with a bigger population to assess the applicability of our results to different age groups. Second, future scholarly endeavors can further our study by conducting a qualitative inquiry to explain the results of our hypothetical testing. Lastly, we did not account for the moderating effects of other variables, such as gender and medical knowledge. We plan to conduct this statistical inquiry in the next phases of this study as this will provide a fertile ground to extract new knowledge about cyberchondria.

As society navigates toward living and working in the new normal, educational institutions must update curricula and support programs to prepare further young professionals to discern the accuracy of medical information online. While young professionals are already outside the university and starting their careers, our findings provide a basis for reforms in three stakeholders: the university, the industry the government. Although fact-checking apps remain a viable technical solution, media literacy across all generations to evaluate valid information online especially social media will be more effective and inclusive (Dumitru et al., 2022; Loos & Nijenhuis, 2020). Our study highlights the need to prepare interns to balance their health, job readiness, and overall well-being for the academe. Therefore, it is crucial to institutionalize programs that will support interns beyond job preparedness and provide critical life skills to balance their health needs and information online about medical information. For the industry, ensuring that newly hired employees are given adequate institutional support beyond healthcare benefits such as professional development programs or training on overall well-being can be implemented as part of their onboarding process. Lastly, this study highlights the need for government bodies to maximize the potential of online spaces to promote and deploy programs to educate young professionals to validate online information and decrease the harmful effects of cyberchondria.

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Using Social Network Analysis to Evaluate Individual Contributions in Online Collaborative Learning Communities: A Case Study of Reading Groups

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Abstract: Research on online collaborative learning communities still faces the challenge of evaluating individual contributions. Social Network Analysis (SNA) has been proposed as an innovative method to facilitate teachers observing group members' social interaction and assessing their learning engagement and performance in collaborative learning activities. Accordingly, adopting a case study approach, this study employed SNA to evaluate individual contributions in online collaborative reading groups. New algorithms were put forward to help identify opinion leaders and detect group polarization in small group reading. The results revealed that the proposed method can be used to successfully recognize opinion leaders and group polarization phenomenon which serves as important information source for teachers to orchestrate and regulate collaborative learning groups. This study provides new insight into using SNA to evaluate individual contributions in online collaborative learning communities.

Keywords: Social network analysis, individual contributions, online collaborative learning, opinion leader, group polarization

1. Introduction

With the development of computer technology, online collaborative learning has been extensively used as an influential teaching paradigm (Hernández-Sellés, Muñoz-Carril & González-Sanmamed, 2019). Under the circumstances of COVID-19 pandemic, it has become an increasingly important method for promoting student interaction in distance learning. Although the benefits of collaborative learning have been well documented in literature, it remains as a challenge for teachers to evaluate individual's contributions in learning groups. This is particularly true in the context of massive online collaborative learning which demands substantial cognitive capacity of teachers to assess multiple groups' learning performance and provide just-in-time scaffoldings and interventions (Bao et al., 2021).

Under this background, the current study aims to evaluate individual contribution with Social Network Analysis (SNA) which has been proposed as an effective way to analyse the interactive model of a group and evaluate students' online discussion performance (He, 2012; Lin, Hu, Hu, & Liu, 2016; Karen, Richard & Roger, 2014). With SNA, this study further evaluated each group member's contribution in online collaborative reading communities in which students needed to work as a group to complete specific reading tasks. Additionally, the study also used algorithms related to centrality measures to make the evaluation more accurate, which can better demonstrate the results of SNA. Eventually, with the support of SNA maps and algorithms, this study successfully evaluated individual contribution in groups, and bridged the gap for research on assessing individual contributions in collaborative learning processes.

2. Method

2.1 Participants

The study conducted an experiment in an undergraduate English language course at a key university in northern China. Students were randomly divided into groups of four to six members, and each group was asked to work together to finish a collaborative reading activity and submit a reding report. To satisfy the need of collaborative reading, this study used Wiki as the platform for students to discuss and write their group reading report. As a collaboration tool, Wiki has been verified to be a beneficial tool when used in online collaborative language learning practices (Li, 2012). One week after the task was issued, all groups submitted their reading reports, and the teacher of the course scored them. Eventually, we had Group A with 4 members who received the lowest score, and Group B with 6 members who achieved the highest score. Adopting a case study approach, we used the discussion data of these two groups to evaluate individual contributions with SNA method.

2.2 Research questions

This study proposed three research questions regarding using SNA to observe students' behavioral contribution, personal influence, and social cognition respectively:

- ★ How can SNA be used to assess individual contributions in small group reading?
- ★ How can SNA be used to identify opinion leaders (OLs) in small group reading?
- ★ How can SNA be used to detect group polarization (GP) in small group reading?

Through the answers to these three questions, this study can not only better illustrate the function of SNA in evaluating individual contributions but can also further identify the most influential individuals (i.e., OLs) and the general trend of social relationship development (i.e., GP) during the whole collaboration process.

2.3 Data analysis methods and algorithms

The study collected online discussion data from the two groups mentioned above and filtered out those invalid ones that were responses that were off topic. After the procedure, the study finally constructed the Social Network Analysis maps (SNA maps) for each group. In addition, to validate the information received from the SNA maps, the study measured the importance of the nodes in the network by calculating the Degree Centrality (DC), and the formula for calculating DC is presented as follows.

$$C_d(v_i) = \sum_{i=1, i\neq j}^{n} w_i^{out}$$

In this formula, *j* denotes all the nodes except node *i*, while *i* denotes the requested node (group member). In addition, *w* stands for weight, which in the SNA map denotes the size of the nodes. Therefore, w_i^{out} represents the weight of the out-degree from *i* to *j*, and the centrality of node *i* (v_i) is the sum of w_i^{out}. Calculation of DC is the direct measurement of node centrality in SNA. The greater the centrality of a node, the more important the individual represented by the node is in the social network relationships.

Considering the different group size, we also normalized the DC to improve the accuracy of the centrality calculation. The normalization formula is as follow, where *n* represents the total number of people in a group:

$$C'_d(v_i) = \frac{C_d(v_i)}{n-1}$$

In this scenario, the practical meaning of the formula is the average number of chats per member to each other member of the group. By comparing the magnitude of the normalized DC (NDC), we can detect the most active member in the group discussion (i.e., OLs) and compare the activeness of the members in the two groups.

Apart from OLs, however, it is also significant to note the general trend shown in the two maps. The gap within the group may be the most decisive factor leading to the different final scores of the two groups. In order to quantify the trend of SNA maps and related data, we introduce another formula:

$$G_p = \frac{\left(C'_d(v_i)\right)_{max} - \left(C'_d(v_i)\right)_{min}}{avg(C'_d(v))}$$

In this formula, G_p stands for group polarization, which describes how a group polarizes in the process of online collaborative learning. $C'_d(v_i)_{max}$ and $C'_d(v_i)_{min}$ denotes the maximum and the minimum of NDC of a group respectively, and $avg\ (C'_d(v))$ represents the average of NDC of a group. The higher the G_p, the greater the gap of participation among members within the group. If G_p exceeds 1, the gap in the group is even more serious.

3. Results

The study finally constructed the SNA maps for the two groups (Figure1&2). The nodes in the maps represent members of the group (A1-A4, B1-B6). Lines between the nodes represent the number of conversations existing between the two members, and the size of the node represents the collection of statements made by this member.

By observing the SNA maps of Group A and Group B, we can find that in Group A, student A2 obtains the largest size and has the thickest lines, while in Group B student B2 demonstrates similar performance, indicating that A2 and B2 may be the most active and influential students in the two groups respectively. Besides, by comparing the SNA maps of the two groups, we can see that the nodes in Group B are generally larger, and the lines are thicker than those in Group A, which indicates that the discussion of Group B members may be more active than that of Group A.

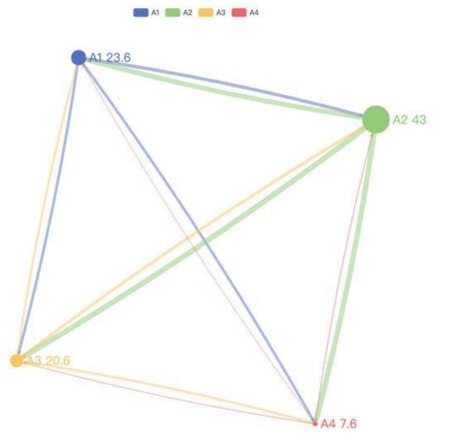

Figure 1. SNA Map of Group A

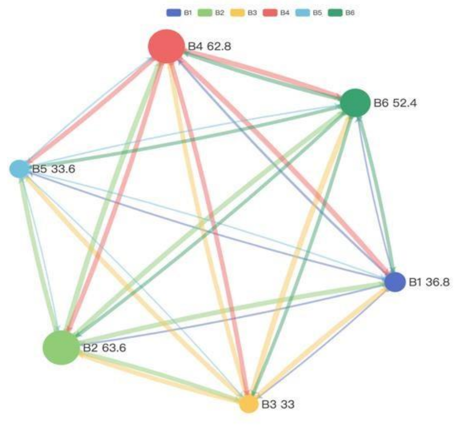

Figure 2. SNA Map of Group B

According to the algorithms, we obtained the quantitative results as shown in table 1 to validate the information received from the SNA maps:

Table 1. *Normalized Degree Centrality (NDC) of Members*

Group A	$C'_d(v_i)$	Group B	$C'_d(v_i)$
A1	23.66	B1	36.8
A2	43	B2	63.6
A3	20.66	B3	33
A4	7.67	B4	62.8
		B5	33.6
		B6	52.4

The results clearly revealed that the most active student or the OL in Group A is A2, while it is B2 in Group B, which is consistent with the information provided by the SNA maps. Besides, with the algorithm of G_p, we can analyze the development trend of group discussion as well. Here, we finally learn that the G_p in Group A is 1.49 and that of Group B is 0.65. Therefore, this study can eventually interpret that the situation in Group A is generally guided by student A2, but the voices or opinions of others may not be well accepted. However, the ideas of students in Group B are better accepted and applied by the whole group.

4. Discussion and conclusion

Now we can answer the three questions the current study has proposed. For research question 1, SNA can generate a social network map connecting the individual data, presenting the general performance of each member as well as the entire group. For question 2 and 3, with the help of the algorithms proposed in this study, we can easily confirm the OLs, and GP revealed by the SNA map.

Existent research about OL points out that OLs can play active and positive roles in guiding group cooperation (Li, Li & Kou, 2022; Li & Wei, 2020). In our study, they did play their roles, but we also need to be aware that GP happened as well. Generally, GP occurs when group members end up being more extreme in their position on a given issue after participating or being exposed to a discussion led by someone (Isenberg, 1986). Thus, during the process of collaborative learning, it is pivotal for teachers as well as students to discover and value ideas from each member, otherwise the positive role of OL may result in a negative outcome as the creativity of others may be stifled.

To conclude, SNA can act as a useful tool when it comes to evaluating individual contributions, identifying opinion leaders, and detecting possible group polarization in collaborative learning. This can serve as important bases for teachers to orchestrate and regulate groups so as to avoid homogenization in online collaborative learning. Future studies can use the results of SAN to further explore how to encourage OLs to prevent rather than intensify GP, which can be an effective method to improve the quality of online collaborative learning.

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Research Status and Hotspots of Pre-service Teachers' ICT in Education Competencies-Visualization Research Based on Citespace

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Abstract: Focusing on "pre-service teacher" and "ICT" as the keywords, this paper adopts Citspace to visualize the knowledge map, and uses the Web of Science as the database to analyze the publishing situation and research hotspots of pre-service teachers' ICT in education competencies from 2002 to 2022. Through keyword co-occurrence network analysis, the paper finds that: Nanyang Technological University has a lot of research achievements in teachers' ICT in education competencies, and the journal of Computer and Education is cited the most. Furthermore, keywords clustering analysis was carried out on the research hotspots, and 10 hotspot issues related to pre-service teachers' ICT in education competencies were obtained, which were roughly divided into teacher education, the application of ICT in education, and the hot theories of informatization teaching.

Keywords: Pre-service teacher, ICT in education competencies, cite space, hotspots

1. Research Background

In February 2022, the Ministry of Education's Department of Teachers' Work issued the "Key Points of the Work of the Department of Teachers' Work of the Ministry of Education in 2022", which clearly pointed out that it is necessary to promote artificial intelligence to boost the construction of the teaching team and further promote the information technology application ability improvement project 2.0. Improving the pre-service teachers' ICT in education competencies of the teaching staff is one of the important indicators to improve the core quality of the teaching staff. And the pre-service teachers are the main force of future teachers. The information awareness and the ICT in education competencies of pre-service teachers have an important influence on the development of education modernization. Under this background, Teacher Education Institutions (TEIs) should actively respond to the requirements, and fight for improving the comprehensive ability of pre-service teacher. (Liu, et al, 2019).

2.Data Collection and Data Analysis

The data of this study comes from the Web of Science. We typed in the keywords "pre-service teacher" and "ICT", selected the time slice as 1 year, and limited the publication time from 2002 to 2022. And then eliminated the less relevant papers, finally got 347 effectively retrieved papers. In order to reveal the research hotspots and development trends of the pre-service teachers' ICT in education competencies in recent years, we adopted the CiteSpace (6.1.R3) software to conduct a detailed map study (Hu & Chen (2014)). In this study, the visualization data in the Web of Science is organized and made into charts to sort out the textual structure, reference analysis, and change trends of the themes.

3. Research Results

Using the Web of Science as paper database, and then classify the papers that meet the requirements. We selected the "(TS= (pre-service teacher)) AND TS=(ICT)" as the search criteria and the time limit was from January 2002 to January 2022. An external analysis of the research on ICT in education competencies of pre-service teacher was conducted on institutional profiles, cited journals and hot issues.

3.1 Institutional Profile

An institution is the unit that authors rely on to publish papers, and the number of papers published by an institution is an important reference standard to measure the institution's scientific research capabilities. We selected the institution by node type and got the institution cooperation network diagram (Figure 1). Modularity is the clustering module value (Q value). It is generally believed that Q>0.3 means that the clustering structure is significant. The Q value in the analysis of the institution is 0.9567, indicating that the clustering structure is significant and convincing. The larger the annual ring in the knowledge graph, the more important the keyword, and the greater the intermediary centrality, the stronger the influence of the keyword (Chen,2017). As illustrated in Figure 1, Nanyang Technology University has the largest annual ring and the largest intermediary centrality. It shows that Nanyang Technology University has the greatest influence.

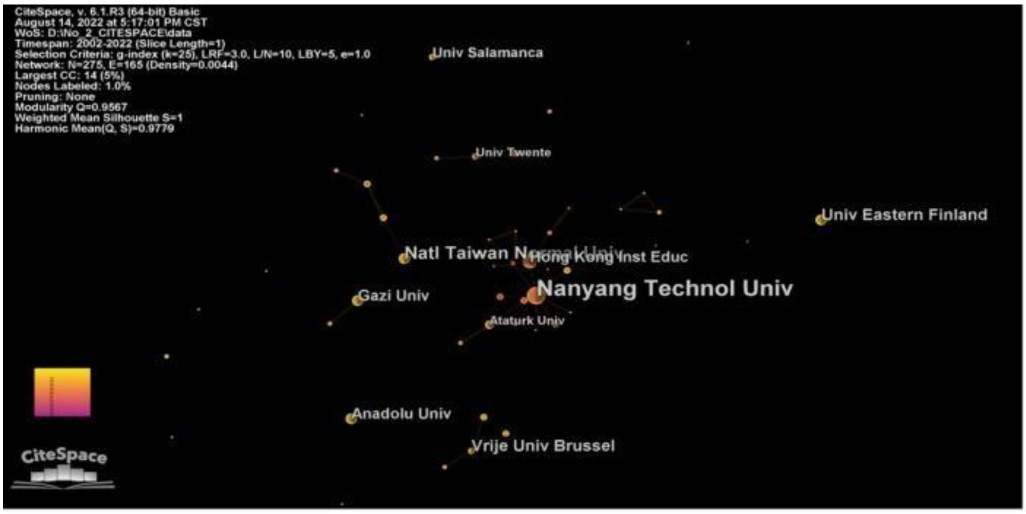

Figure 1. Institutional Cooperation Network Diagram

In order to have a clearer understanding of the specific number of papers published by each institution, we sorted out the number of papers published by each institution, and listed institutions that have published no less than 6 papers in the past 20 years (Table 1).

Table 1. *Institutions and Numbers of Published Papers*

Serial Number	Institution	Numbers of Paper
1	Nanyang Technological University	19
2	Taiwan Normal University	9
3	University of Eastern Finland	7
4	Free University of Brussels	7
5	Hong Kong Institute of Education	6
6	Gazi University	6
7	Anadolu University	6

As shown in Table 1, Nanyang Technological University has published the most papers on ICT in education competencies with 19 papers, followed by Taiwan Normal University with 9 papers. Among the top seven institutions, three are located in the Asia-Pacific region, and the total number of publications is 34, accounting for 56.6% of the total number of publications by the top seven. This shows that the Asia-Pacific region regards pre-service teacher informatization training as an important research field. Taking Singapore as an example: there have been 4 ICT-in-Education Masterplans since 1997 in Singapore. Four versions of ICT-in-Education Masterplan were implemented from 1997 to 2019. Currently, Singapore is conducting an Educational Technology (EdTech) Plan, which guides the development of a technology-enriched school environment for teaching and learning.

3.2 Cited Journals Analysis

Citespace was adopted to analyze the citations of the papers, and the journals to which the cited papers belonged were counted. Journals with more than 100 citations are listed in the table 2. It can be obtained from the table: the *journal of Computer and Education* was cited the most with 224 times, the *Journal of Computer Assisted Learning* was cited 127 times. This statistic provides readers with a list of journals, which have a high correlation with pre-service teachers' ICT in education competencies.

Table 2 *The counts of cited Journals*

Serial number	Cited Journals	Count
1	Computer and Education	224
2	Journal of Computer Assisted Learning	127
3	British Journal of Educational Technology	119
4	Australian Journal of Educational Technology	119
5	Teaching and Teacher Education	117
6	Computers in Human Behavior	106
7	Educational Technology Research and Development	103
8	Educational Technology and Society	102
9	Teachers College Record	101
10	Journals of Research on Technology in Education	100

3.3Analysis of Hot Issues

Co-word analysis technology is a text content analysis technology that explores the development of the discipline by analyzing the characteristic relationship of co-occurring words (Pan L & Jiang H, 2016). Keywords must appear in the core content of the paper, so the keywords of the paper are a trustworthy indicator. We adopted "pre-service teacher" and "ICT" as keywords, and perform keyword cluster analysis on the keywords, and finally got 10 clusters. The order of the cluster is from 0 to 9, the smaller the number, the more keywords contained in the cluster. Each cluster is composed of multiple closely related words.

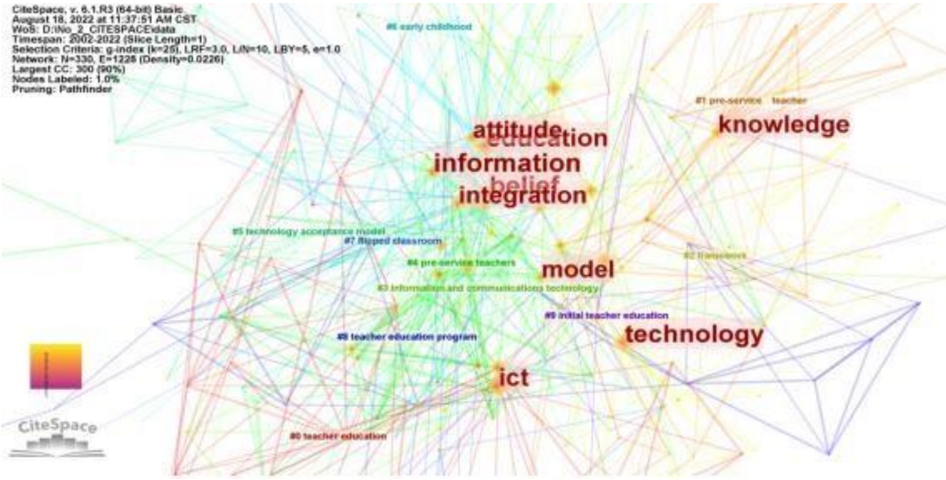

Figure 2. Keyword heat map

As can be seen from the figure, keywords related to pre-service teachers' ICT in education competencies include #0teacher education, #1pre-service teacher, #2framework, #3information and communications technology, #4pre-service teachers, #5technology acceptance model, #6early childhood, #7flipped classroom, #8teacher education program, #9inital teacher education.

According to the field of the keyword, we roughly divide the keywords into three categories: the “teacher education", "pre-service teacher(s)", "initial teacher education", "teacher education program" belong to teacher education, while the application of information technology in education includes "flipped classroom" "early childhood". What is more, the popular theories and professional terms include "information and communications technology", "framework" and "technology acceptance model". Therefore, the research hotspots in the past 20 years have focused on teacher education, the application of information technology and theoretical research.

4. Summary

Teachers in the ICT-mediated learning environments have to take on the more demanding role of a mediator and a knowledge broker: to provide guidance, strategic support, and assistance to help students at all levels to assume increasing responsibilities for their own learning. Inevitably, these questions have serious implication on how school teachers should be educated (Jonassen, et al., 2008; Kirschner & Selinger, 2003; Lock, 2007; UNESCO, 2008).

(1) The leaders of education institutions are supposed to hold a comprehensive vision. The ICT in education vision developed by TEIs may need to be reviewed as the needs of schools and society change with the advancement of ICT.In order to cope with the changes and advancements, the leaders of should actively take a series of measures from top to bottom: schools adjust their awareness and concepts, add more ICT elements, and adjust the teaching concepts of pre-service teacher trained to adapt to the school and society.

(2) An effective and robust pre-service teacher education program will prepare teachers with the necessary ICT and pedagogical competencies to integrate ICT for teaching, learning and administration in schools (Mims, Polly, Shepherd, & Inan, 2006). In the curriculum system for cultivating pre-service teacher, pre-service teacher not only learn subject knowledge and pedagogical knowledge, but also combine ICT with it, and integrate ICT into teaching.

(3) The authorities should issue documents to assist the implement of ICT infrastructure, resources and support strategies. Setting up technology infrastructure require consideration of available physical infrastructure. These devices must be allowed expansion and, as technology develops, be able to adapt accordingly. In addition, these ICT infrastructures must be equipped with software systems, management systems, etc.

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Blended Learning Facilitated Adult Training: A Case Study on Blended Learning and Application in Agricultural Meteorology Course

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Abstract: This paper discusses the connotation and significance of blended training and introduces the process of implementing blended training. This paper elaborates the case of implementing blended training, and finds out the highlights, advantages and challenges of blended training through the case. Finally, it discusses how to implement blended training in on-the-job training to realize the combination of online and offline.

Keywords: Blended training, Blended teaching, On-the-job training, Hybrid learning, Flipped learning

1. The concept of blended training

Blended training is to combine the advantages of traditional face-to-face training with the advantages of web-based learning. It should not only play the leading role of teachers in guiding, inspiring and monitoring the teaching process, but also fully reflect the initiative, enthusiasm, and creativity of students as the main body of the learning process. BadrulH.Khan (2002), a US scholar, proposed the Eight-Dimensional Framework of blended learning, pointing out that since each student has different learning requirements and performance, training institutions must use mixed programs in training strategies, so that appropriate content can be taught to appropriate people at appropriate time and under appropriate arrangements. According to domestic scholars Ronghuai Huang, the purpose of blended learning is to integrate the advantages of classroom teaching and web-based teaching, comprehensively adopts the mass instruction form mainly led by teachers, the group learning form based on the concept of cooperation and the distance teaching form mainly led by independent learning, and comprehensively use different learning theories, different technologies and methods and different application ways to implement teaching. Professor Fuyin XU pointed out that the teaching view emphasizes the interaction between teachers and students, the active construction of knowledge by learners, and the learning in activities and problem-based learning in the information age.

Blended training is the design of blended training strategy based on the core of achieving training objectives, which is carried out at three levels: online and offline, culture and training, and learning and work. Its main feature is to widely choose the use of remote platform, practical training, face-to-face training and learning resources; At a higher level, we should make full use of "training" to apply the learning content to the simulation practice. In the deeper field, the effective use of "action learning" makes the staff training directly combine with the actual work, solves the problems existing in the management, production, and operation of the organization, promotes knowledge management, and realizes the continuous improvement of the organization.

2. Implementation process of blended training

Skills training program is suitable for blended training. General skills learning can be completed online, and specific problems can be solved in centralized teaching. Job adaptability training is also more suitable for blended training. Basic theoretical knowledge can be learned online, and the knowledge and skills with strong practical ability can be learned in centralized training.

2.1 Define the tasks of carrying out blended training

The main tasks of carrying out blended training are as follows: First, to strengthen teachers' understanding of distance platform and the concept of blended training, the key is to recognize the advantages of distance training in blended training, promote teachers' attention to blended training mode, and encourage teachers to actively invest blended training mode into practice. The second is to improve the blended training ability of trainers and training managers based on the remote platform, including the ability to design and implement blended training programs. Third, sort out the process of blended training, and establish the system and mechanism to promote the effective development of blended training.

2.2 Standardize the process and implement the systematic blended training design

In the development and design process of each training project, systematic blended training design is implemented according to three stages of "before training, during training and after training" and there are five steps of blended training, that is demand analysis, blended strategy design, curriculum development, training implementation and training summary.

Blended training is based on the realization of training objectives. In the implementation of blended training project, a variety of training methods are used to ensure effectiveness, including a new blended training model integrating "face-to-face learning, online learning, on-site learning and action learning". Among them, face-to-face training mainly adopts problem-oriented training, that is, the trainer organizes the students to discuss and summarize the problems before the training, and the experts give lectures on the problems during the teaching. Online learning takes distance courses according to the seminar theme. On-site teaching is based on face-to-face teaching to deepen theory and expand knowledge, exchange problems solution with experts, see the actual operation of the business on the site, find and solve problems on the site. Action learning is mainly through the participants to solve the practical problems encountered in the work, learners reflect on their experience, learn from each other and improve.

Blended training should start from practical learning and implement effective integration of multiple mixed levels. Different blended training projects, aiming at different training objects, choose different links to highlight the mixed depth and mixed emphasis, strengthen the characteristics of blended training, and give full play to the unique advantages of blended training.

2.3 Make good connections and a real systematic blended implementation

First, face-to-face teachers need to understand distance training, especially the learning resources provided by the platform and the main functions of the platform. Starting from the practice of blended training, there are several problems affecting the promotion of blended training. They are the practice of courseware production, the functions that can be adopted by the blended training provided by the distance training platform, the quality and ability of the trainers. Through the analysis, it is found that there are three main reasons. First, the objective and planning of blended training is not clear enough; Second, trainers know little about the functions of blended training provided by remote platforms; Third, the trainers are not proficient in the operation methods of the main steps that affect the quality of blended training.

The second is to develop a systematic blended training plan. Every year, we make teaching and research plans, remote courseware development plans, and departmental hybrid training project plans for blended training. Through training, research, practice, we promote problem solving and goal realization.

Third, after the completion of the blended training project, the problems and experiences of hybrid training should be exchanged. Training and discussion should be focused on the available functions of remote platform blended training, alternative ways of blended training, sharing and exchange of blended training experience and other topics.

3. The practice of blended training

3.1 Basic Information

Based on the concept and method of blended training, China Meteorological Administration Training Centre held the second and third training program of basic knowledge and technology of agricultural meteorology. The course content focuses on the basic theories and principles of the discipline. The network course used is based on the Principles of Agricultural Meteorology compiled by Feng Xiuzao, Tao Bingyan et al., and developed by China Meteorological Administration Training Centre and Nanjing University of Information Science and Technology. The training content is mainly for the first-line service personnel of agricultural meteorology at municipal and county-level grass-roots stations all over the country. At the end of the study, they need to take the online examination, and the examination results will be used as the main basis for participating in the relevant face-to-face training qualifications organized by China Meteorological Administration Training Centre.

The distance training of basic theories and principles of agricultural meteorology lasted nearly 11 weeks. In order to answer the students' questions and improve the learning effect, three pre-test counseling and question-answering activities were organized by using the synchronous classroom of China Meteorological Distance Education Platform during the training. In the Q&A process, the students asked the teachers questions in real time through the audio and video function and text chat function in the synchronous classroom. The teacher not only answered the students' questions, but also explained the key and difficult points of the training course and selected 80 typical questions for targeted analysis and explanation based on the examination knowledge points. Besides, during the training, learning support services were provided by interactive communities, telephone calls and QQ learning groups. Two agricultural meteorological business experts were invited to join the QQ group to provide learning support, which guided the students to actively participate in teaching activities and improve their learning initiative.

In order to evaluate the students' learning situation and training effect, after the training, the students who meet the requirements of the class hours are organized to take online examinations. Taking the method of randomly selecting questions from the test bank, the scores of students showed obvious normal distribution. Among them, 113 students scored less than 60 points, accounting for 12.5% of the total number of students, and 120 students scored more than 85 points, accounting for the total number of students 13.3%. Most of their scores are in the 70-79 range.

After the examination, the results of the trainees shall be exported and provided to the face-to-face training teachers. When the notice of face-to-face training is issued, the training objects shall be the first-line service personnel of agricultural meteorology at the municipal and county level in each province who have participated in the online training of basic theories and principles of agricultural meteorology organized by CMATC and passed the examination. Through face-to-face training, students can further systematically understand and master the basic concepts and principles of agricultural meteorology as well as the common technologies and methods of agricultural meteorology business and improve their ability to solve practical problems in agricultural meteorology business service.

3.2 Highlights and advantages of blended training

3.2.1 Arouse the learning enthusiasm of students, and the professional basis of face-to-face training objects is relatively consistent

Distance training, as the pre-training of face-to-face training, is a useful attempt of blended training of China Meteorological Administration Training Centre. Distance training examination score is an important threshold for obtaining face-to-face training qualification. On the one hand, this approach can stimulate students' learning motivation and arouse students' initiative and enthusiasm in distance learning. On the other hand, it can screen out students at the same level of professional knowledge for face-to-face teaching. The professional basis of students is relatively at the same level, so it is convenient for face-to-face teachers to design and develop training courses and improve the training effect.

3.2.2 Blended training not only mixes training forms, but also fully mixes training content

The combination of distance and face-to-face teaching is not only reflected in the training form, the training content is also fully connected. Considering that most of the personnel engaged in the front-line service of agricultural meteorology at grassroots stations are not majored in agricultural meteorology, and the basic theoretical knowledge of agricultural meteorology is relatively weak, the distance training focuses on agriculture basic theories and principles of meteorology, while face-to-face training focuses on the application and practice of agricultural meteorology. As the trainees said: "Distance training learning is a warm-up, is to have a basic outline and preliminary understanding of agricultural meteorology. Face to face training is to strengthen cognition and specific applications of agricultural meteorology. "

3.2.3 Systematic courses, professional teachers ensure the quality of online courses

The online course of this training is an undergraduate course developed by China Meteorological Administration Training Centre and Nanjing University of Information Science and Technology in the form of remote training. The course is edited into more than 150 small courseware, each is about 20 minutes according to the knowledge points. The course is divided into seven chapters, which is convenient for students to learn systematically according to the knowledge points at any time. In addition, the course of learning materials are complete, syllabus, exam syllabus, teacher lecture notes, electronic textbooks, Q&A materials are available for download and is convenient for offline review.

3.3 Deficiency and reflection of practice

The blended training of basic knowledge and technology of agricultural meteorology is a preliminary attempt of blended training, which is only based on the mixture of teaching methods and teaching content. In the process of implementation, online learning and face-to-face teaching are still separated, and there is still some distance from the real blended training. Blended training requires systematic teaching design and blended strategy design, and the face-to-face and remote teaching content is systematically arranged according to knowledge points, the difficulty degree and the teaching requirements. At the same time, the relationship between remote and face-to-face teaching is closely linked to each other. The learning materials and offline tasks of face-to-face teaching can be completed by using the remote platform, and the learning management record of students can be completed at the same time. To do blended training well, first of all, the business barriers of remote and face-to-face teaching should be broken, and at the same time, systematic design and evaluation should be strengthened, so as to give full play of the advantages and benefits of blended training.

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A Mobile Learning Approach to Promoting Students' Learning Performances in The Era of The Pandemic

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Abstract: Educators have indicated the need to foster students' ability to solve problems by acquiring up-to-date knowledge as well as promoting their competencies for making decisions from diverse perspectives based on the acquired knowledge. Traditional courses mainly use lecture-based instruction without providing sufficient opportunities for students to practice and interact with the teacher; therefore, it is difficult to deliver such up-to-date knowledge via traditional instruction, not to mention fostering students' critical thinking. In this study, a Mobile technology model is proposed to address this problem. Moreover, a learning system is developed based on the proposed approach. To evaluate the effectiveness of the proposed approach, a quasi-experiment was conducted in a university with a two-group pre-test post-test design to assess participants' learning achievement and critical thinking. The participants were two classes of undergraduate students. One class with 37 students was the experimental group learning with the Mobile technology learning approach, while the other class with 37 students was the control group learning with the conventional technology-based learning (CTL) approach. Analysis of covariance (ANCOVA) was performed to evaluate the effect of the intervention on the target outcomes. It was found that the experimental group showed better learning achievement and critical thinking than the control group. This implies that the Mobile technology approach has good potential in helping learners think from diverse perspectives and promoting their learning performance and engagement, which is important in higher education aimed at fostering students' competence in acquiring up-to-date knowledge for solving problems.

Keywords: Decision making, mobile learning, critical thinking, mobile applications

1. Introduction

Fostering students' ability to solve problems by acquiring up-to-date knowledge as well as assessing the acquired content from diverse perspectives has been emphasized by educators as important competencies in the 21st century (Albahlal, 2019). From the perspective of constructivism and connectivism, shifting the power in education away from individuals, such as learners and instructors, to a collective group is important (Bozkurt, 2017). It closely aligns to learning that harnesses technology to take learners beyond the walls of the classroom, such as handheld devices and VR (Thongkoo, Panjaburee, & Daungcharone, 2019). Connectivism is positioned as a new philosophy of education for the digital age (Siemens & Conole, 2011). It makes Vygotsky's concept of the zone of proximal development (ZPD) more flexible as well as expanding it to include learning that lies outside the learner, in social networks and technological tools (Mattar, 2018). For example, Cavus and Uzunboylu (2009) pointed out the importance of fostering students' ability to acquire up-to-date knowledge in a mobile web learning environment. In traditional instruction for undergraduate students, teachers generally deliver the content of textbooks and some illustrative cases reported in research articles in a lecture-based mode. In such a learning mode, students have few opportunities to acquire knowledge on their own, not to mention learning to make judgments using the acquired knowledge (Lai & Wu, 2012). Scholars have therefore pointed out the need to shift the educational paradigm to the learner-centered mode, which encourages students to acquire up-to-date knowledge from diverse channels (Schutte et al., 2017). In the era of mobile and wireless communication, such a knowledge-acquiring mode is very important, in particular in the time of the COVID-19 pandemic (Onyema et al., 2020). We introduced the Mobile technology approach in an attempt to overcome the shortcomings of the conventional learning approach and ultimately to enhance students' learning achievements and critical thinking. To verify the efficacy of this model, we used a quasi-experiment to answer the following research questions:

1. How does the Mobile technology learning approach influence student learning achievements in comparison with the conventional technology-based learning (CTL) approach?
2. How does the Mobile technology approach influence student critical thinking in comparison with the CTL approach?

2. Quasi experimental design

2.1 Participants

The participants were two classes of undergraduate students taking a nutritional assessment course at a nursing school in Taiwan. The course is a compulsory basic nursing course in schools and hospitals and is a necessary part of nursing training. One of the classes with 37 students was assigned to be the experimental group using the Mobile technology approach, while the other class with 37 students was the control group learning with the CTL approach. Both classes were taught by the same instructor who had more than 10 years' experience of teaching nutritional assessment and nursing courses. The average age of the students was 21 years old. Pre- and post-test experiments were designed to compare the two groups of students' learning achievement, and critical thinking.

2.2 Experimental procedure

This quasi-experiment was conducted over a period of 4 weeks (two sessions with a total of 100 minutes each week). In the 1st week, the students received the pre-test and pre-questionnaires after learning the basic knowledge of the course unit. In the 2nd and 3rd weeks, the lecturer first introduced the nutritional assessment course and explained the activity and case study instructions. Students were asked to provide nutritional assessments and suggestions based on each case, then took the pre-test and critical thinking pre-questionnaire to understand the students' relevant prior knowledge and feelings. During this learning stage, the experimental group learned with the Mobile technology approach for the nutrition assessment course. Conversely, the control group learned through the CTL approach; that is, teachers used the Daily Diet Guide and PPT (PowerPoint) to explain the content and cases. The content learned by the two groups of students was the same. The worksheet included information about whole grains, beans, fish, eggs, meat, dairy products, vegetables, fruit, oils, nuts, and seeds, and to practice nutritional evaluation skills for providing dietary suggestions. During the practice and discussion stage, both groups of students could then ask and discuss any nutritional assessment questions with teachers or classmates. This enabled peers to practice with each other according to the worksheet.

2.3 Experimental Results

This study used the pre-learning test as the covariate for analysis and the post-learning test as the dependent variable. The Levene's test revealed that the homogeneity assumption was confirmed for learning achievement F (1, 70) = 0.04 ($p > 0.05$). In addition, after verifying that learning achievement scores F (1, 72) = 8.75 ($p > 0.05$) complied with the assumption of regression homogeneity, we used ANCOVA for post-hoc analysis of the scores of the two groups. Here, we used a visit method for ANCOVA analysis. As shown in Table 1, the learning achievement F (1, 71) = 22.87 (95% confidence interval 17.86 to 32.51; $p < 0.001$) results suggested that the intervention was effective. Students using the Mobile technology learning approach had better learning achievement results (mean = 88.66; SD = 10.84) compared to students learning with the CTL approach (mean = 63.47; SD = 19.55).

In addition, after verifying that critical thinking ratings F (1, 72) = 8.79 (p > 0.05) complied with the assumption of regression homogeneity, we used ANCOVA for post-hoc analysis of the scores of the two groups. Here, we used a visit method for ANCOVA analysis. The critical thinking F (1, 71) = 44.57 (95% confidence interval 0.87 to 1.38; p < 0.001) results suggest that the intervention was effective. Students using the Mobile technology approach had better critical thinking results (mean = 4.56; SD = 0.52) compared to students learning with the CTL approach (mean = 3.43; SD = 0.58).

Table 1. *learning result of learning achievement and critical thinking*

Variance	Group	*N*	Mean	*SD*	Adjusted mean	*Std. error.*	*F*	*η2*
Learning achievement	Experimental group	37	88.66	10.84	85.81	2.69	22.87^{***}	0.244
	Control group	37	63.47	19.55	66.32	2.69		
Critical thinking	Experimental group	37	4.56	0.52	4.41	0.08	44.57^{***}	0.386
	Control group	37	3.43	0.58	3.58	0.08		

$^{***}p < .001$

3. Discussion and Conclusions

The contribution of the present study is to propose the Mobile technology learning approach and examine the effectiveness of guiding students to make decisions, acquire up-to-date knowledge via mobile applications, and make reflections before doing exercises in professional training programs. By associating the statements in the literature review and the discussion, it was found that the Mobile technology approach can be fully supported by the literature and several educational theories. More importantly, the barriers to implementing the Mobile technology approach in professional training are low, and hence the findings of the present study could be a good reference for those who intend to conduct research and instruction in professional training programs in the future. In particular, in the time after the pandemic, the findings could be a good reference for helping students learn how to keep track of the pandemic and make suitable decisions to protect themselves and their families. As suggested by several scholars, educating students to learn up-to-date knowledge is very important in the pandemic and post-pandemic eras.

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The Development and Evaluation of a Gamified Virtual Heritage Tour for Cultural Learning: A Perspective of Cognitive and Affective Immersive Learning

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Abstract: This study aimed to integrate gamified mechanism into the design of a web-based virtual heritage tour for cultural learning. There were five core drives of gamification used in this study including (1) *epic meaning & calling*, (2) *development & accomplishment*, (3) *empowerment of creativity & feedback*, (4) *ownership & possession*, and (5) *unpredictability & curiosity*. With 40 post-secondary students' survey responses, we also evaluated the virtual tour from the perspective of cognitive and affective immersive learning. The results showed that the students expressed stronger cognitive perceptions (cognitive benefit) than affective senses (spatial presence and flow experience) when engaging in the gamified virtual heritage tour. The crucial role of the affective variables rather than the cognitive variable in learners' perceived learning outcomes was also identified. The research data of this study has been continuingly collected. We also indicated several directions for this work in the future.

Keywords: Gamification, virtual reality, heritage, cultural learning, presence, flow

1. Introduction

Past research has indicated the significant role of virtual reality (VR) technology in cultural heritage education (Carrozzino & Bergamasco, 2010; Sylaiou et al., 2010). With the affordance of VR, cultural heritage could be reconstructed in the virtual world for the cultural preservation and communication, particularly for the purposes of cultural learning. Virtual tour, a VR application for users to virtually navigate certain places without physical visit has been increasingly exploited to the field of cultural heritage tourism (Debailleux et al., 2018; Guan et al., 2020). Previous studies addressed that the virtual heritage tour was able to enhance users' attention and motivation to cultural learning (Han et al., 2020; Poux et al., 2020), as well as to foster their understandings of intangible cultural knowledge (Mah et al., 2019). However, it has been argued that simply navigating in spherical video-based (also known as VR360) virtual environments without interaction with cultural contexts could not remain intention to engage in virtual tours and may not acquire in-depth cultural understandings. The integration of gamification into the design of virtual tour was therefore suggested by a recent study (Argyriou et al., 2020). Following the ideas, this study considered that the design of a gamified virtual heritage tour for cultural learning should be explored.

The issue regarding learners' perceptions of immersive learning when engaging in virtual learning environments has been noted in recent VR research. For example, Makransky and Lilleholt (2018) identified the essential role of several cognitive and affective variables in learners' perceived learning outcomes. It was found that, in a cognitive path, the learners' perceptions of cognitive benefit significantly predicted their perceived learning outcomes. On the other hand, the variable of presence was an antecedent to the perceived learning outcomes in an affective path. Similar findings were found in the research of spherical video-based virtual museum navigation, indicating the importance of affective perceptions such as spatial presence in behavioral attitudes (Cheng, 2021). Moreover, researchers have paid attention to explore to what extent that learners were involved in in the context of game-based learning through the evaluation of flow experience. In general, individuals' flow experience was documented its benefits for learning engagement and outcomes (Perttula et al., 2017).

In sum, the purpose of this study was to develop a gamified virtual heritage tour application for cultural learning in the context of Taiwanese culture. To evaluate the gamified virtual heritage tour developed by this study, we aimed to include the cognitive variable of cognitive benefit and the affective variables of spatial presence and flow experience to examine how these variables influence learners' perceived learning outcomes (i.e., perceived learning and behavioral intention) through the perspective of cognitive and affective immersive learning.

2. Method

2.1 The gamified virtual heritage tour application

With the utilization of spherical video-based VR techniques (VR360), this study developed a web-based virtual tour application for cultural learning of a Taiwanese heritage commemorating a famous woman with chastity in Taichung County. As shown in Figure 1, learners can freely transport to certain positions of the heritage and observe the panoramic scenes. Several hot spots on the scenes can be interactively triggered for attaining additional information such as the cultural background of the heritage and the features of the heritage in details.

To enhance learning motivation for the cultural knowledge, this study integrated the Octalysis gamification mechanism (Chou, 2015) into the design of the virtual tour application. Specifically, there were five core drives of gamification used in this study including (1) *epic meaning & calling*, (2) *development & accomplishment*, (3) *empowerment of creativity & feedback*, (4) *ownership & possession*, and (5) *unpredictability & curiosity*. For instance, for achieving the goal of *epic meaning & calling*, learners act as an explorer to accomplish the tasks which the virtual tour assigned to. Through the design of *unpredictability & curiosity* and *empowerment of creativity & feedback*, there were several puzzles situated in the virtual scenes for learners to seek, solve, and acquire feedback hints for understanding the cultural context of the heritage. Learners can also increasingly collect badges by solving the puzzles for achieving the gamified drives of *development & accomplishment* and *ownership & possession.*

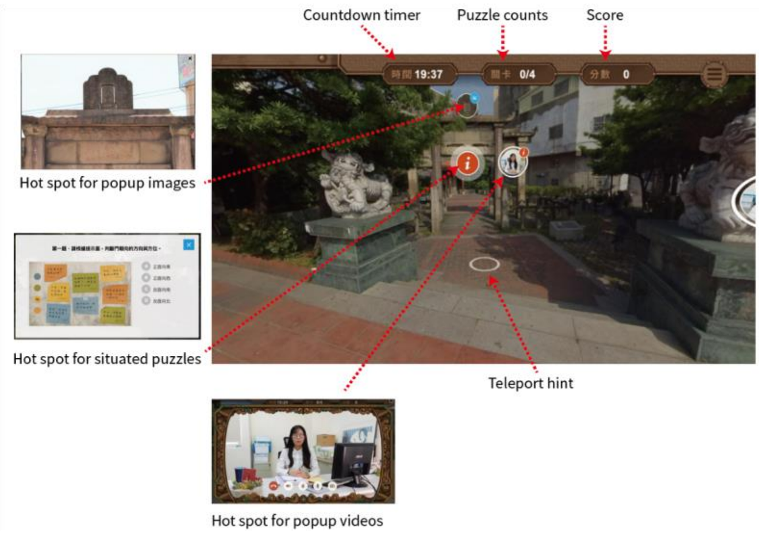

Figure 1. The interface of the gamified virtual heritage tour application.

2.2 Respondents and research procedure

This study recruited 40 post-secondary students (22 females and 18 males) to participant in the virtual heritage tour for cultural learning. The mean age of the students was 25.38 years old (*SD*=6.17). Firstly, the students were invited to freely use the virtual tour application through desktop PCs. The average duration for the virtual cultural learning was approximately 20 minutes. The students were required to respond to the questionnaire of this study (described later) for understanding their cognitive and affective perceptions of immersive learning.

2.3 Instrument

The scale of *spatial presence* used in Cheng's (2021) study and the scale of *flow experience* used in Kim and Ko's (2019) study were adopted to examine the students' affective perceptions of immersive learning. Moreover, this study adopted the scale of *cognitive benefit* used in Makransky and Lilleholt's (2018) study to probe their cognitive perceptions of immersive learning. The scales of *perceived learning* and *behavioral intention* (Makransky & Lilleholt, 2018) were also adopted to understand how the students' cognitive and affective perceptions of immersive learning influenced their perceived learning outcomes. All the scales were measured on a five-point Likert scale ranging from strongly disagree (1 point) to strongly agree (5 points). The Cronbach's α of these scales were all higher than 0.7, indicating the acceptable reliability of the measurement in this study.

3. Results and discussion

The results of the repeated ANOVA analysis for the students' cognitive and affective perceptions of immersive learning showed that their perceived cognitive benefit (M=3.99, SD=0.74), perceived learning (M=3.79, SD=0.74), and behavioral intention to visit the physical heritage (M=3.74, SD=0.85) were significantly stronger (F=8.81, p<.001) than their affective perceptions of immersive learning such as flow experience (M=3.49, SD=0.88) and spatial presence (M=3.61, SD=0.94). Further correlation analysis for the variables of cognitive and affective immersive learning in this study revealed that there were significant relationships among the students' flow experience, spatial presence, cognitive benefit, perceived learning, and behavioral intention. Subsequent results of the stepwise regression analysis showed that the students' affective perceptions of flow (β=0.51, p<0.01) and spatial presence (β=0.40, p<0.01) rather than cognitive perceptions significantly predicted their perceived learning in the context of virtual heritage tour, with 71% of explained variance. The students' willingness to visit the physical heritage was significantly predicted only by their flow experience (β=0.81, p<0.001) in the learning activity, with 64% of explained variance.

To summarize, although the students expressed stronger cognitive perceptions than affective senses when engaging in the gamified virtual heritage tour for cultural learning, this study identified the crucial role of the affective variables (flow experience and spatial presence) rather than the cognitive variable (cognitive benefit) in learners' perceived learning outcomes. The findings of this study were similar to the results addressed by the previous VR research (e.g., Parong & Mayer, 2018). The research data has been continuingly collected for this work. With a large sample size, the structural relationships among the variables of this study could be examined through structural equation modeling analysis for verifying the cognitive affective model of immersive learning (CAMIL) proposed by Makransky and Petersen (2021). We also attempt to examine the instructional effectiveness of the gamified virtual heritage tour for cultural learning through the experimental research design (e.g., gamification vs. non-gamification) in the future.

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In-Course Progressive Prediction and Recommendation for Supporting Personalized Learning

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Abstract: Personalized learning is known as an effective educational approach. Individual students' performance-based recommendations for learning improvement can be useful in supporting personalized learning. In this paper, we propose an in-course fine-grained progressive performance prediction and recommender system that provides recommendations of study topics, materials, and activities, and peers based on predicted grades to help guide individual students for personalized learning within a course. The performance prediction is based on collaborative filtering on the grades of courses and the grades of the course assessments in a course. This in-course prediction and recommendation can be a useful personalized learning supporting tool by continuously and progressively guiding individual students to prepare and do better in the course assessments throughout the entire course.

Keywords: Personalized learning, Personalized in-course prediction and recommendation, Learning activity recommendation, Peer recommendation, Grade and performance prediction, Collaborative filtering

1. Introduction

Personalized learning is recognized as an effective educational approach that focuses on individual student-centered learning (Grant, & Basye, 2014). It is important in both in-person and online learning environments. Personalized learning in the context of higher education is reviewed in Zhong (2022). A variety of technology-enhanced personalization and differentiation methods are used to support personalized learning. Current trends in learning path personalization and learning content recommendations in adaptive and personalized learning environments are summarized in Nabizadeh et al (2020) and Raj, and Renumol (2021). The Mastery Paths feature in the Canvas learning management system (LMS) is used in practice to design a personalized learning experiences for individual students through differentiated assignments based on students' actual performances in assignments (Paradiso, & Chen, 2021).

Peer learning is an essential educational practice that is based on student learning from and with other students in both formal and informal ways (Boud et al., 2014). Zhang, and Bayley (2019) reported peer learning in the context of higher education. Peer learning is often facilitated through group activities such as peer study group. Various peer recommendation methods have been proposed (Khosravi et al., 2017; Potts et al., 2018; Thanh et al., 2019).

Predicting individual student's performance in courses can be helpful for students to get better perspective and prepare better for the courses. There have been various course-level grade prediction methods (Hellas et al., 2020). A variety of educational prediction and recommender systems have been proposed and used in various educational subdomains including technology-enhanced learning (Drachsler et al., 2015). Collaborative filtering is a widely used and proven method for personalized predictions and recommendations (Aggarwal, 2016; Ricci et al, 2015).

In this paper, we propose an in-course fine-grained progressive prediction of personalized performances on graded course assessments using collaborative filtering, and based on the predicted performances, recommendation of personalized study topics, materials, activities, and various types of peers (classmates) for peer learning. Our goal is to help guide individual students achieve better actual performances in the graded assessments in a course through personalized learning activities based on the recommendations throughout the entire course.

2. Progressive Prediction and Recommendation

Given a course, we build an in-course prediction and recommender system called *myCourseMentor* for supporting personalized learning progressively within the course. Our personalized prediction and recommendation are based on collaborative filtering on the students' final course grades in all courses including the given course and students' performances in all course assessments in the given course. We maintain a student-course-letter-grade data and a student-course-assessment-performance data. Assume that course grades and course assessment performances are represented as numeric scores ranging from 0 to 100.

Each course has a set of measurable learning objectives (LO). Each learning objective is linked to a set of lesson topics (LT) to be covered, a set of learning materials (LM) to be used and a set of learning activities (LA) to be done by students and a set of graded learning assessments (GA) to be evaluated whether students achieve the learning objectives. Learning assessments are aligned with learning objectives through learning topics, material, and activities. A course C is viewed as follows:

$$C: LO \leftrightarrow \{LT\} \leftrightarrow \{LM\} \leftrightarrow \{LA\} \leftrightarrow \{GA\}$$

There are diverse types of graded assessments including quizzes, homework assignments, discussions, tests, exams, and projects. All graded assessments are also graded as numeric values ranging from 0 to 100. We also maintain a student-assessment-grade data.

Suppose that a course C consists of a sequence of *n* graded assessments GA_1, GA_2, …, GA_i, …, and GA_n, i.e.,

$$[GA_1, GA_2, \ldots, GA_{i-1}, GA_i, GA_{i+1}, \ldots, GA_n]$$

and let T_i be the learning time after GA_1, GA_2, …, GA_{i-1} have been completed and before GA_i begins, i.e.,

$$[T_1, GA_1, T_2, GA_2, \ldots, T_{i-1}, GA_{i-1}, T_i, GA_i, T_{i+1}, GA_{i+1}, \ldots, T_n, GA_n]$$

Given a target student S, a course C and a learning time T_i during a semester, our in-course prediction and recommender system predicts the student's expected grade in each graded assessment to be completed after T_i, and recommends the personalized study topics, materials, and activities as well as personalized peers for the target student to do better in each graded assessment. The prediction and recommendation process for GA_i is as follows:

1) Predict the grade of S in a graded assessment GA_i via the student-to-student-based collaborative filtering.
   - We compute the similarity values between S and all classmates based on the grades in the courses and the grades in the graded assessments GA_1, GA_2, …, GA_{i-1} that both S and all classmates have completed.
   - The predicted grade of S in GA_i is computed as a weighted average of the top k most similar students' grades in GA_i. Let PG_i be the S's predicted grade in GA_i.
   - Here, k can be tuned and other collaborative filtering techniques instead of the student-based collaborative filtering can be used.
2) Recommend personalized differentiated learning topics (LT), learning materials (LM), and learning activities (LA) for GA_i based on the PG_i range, i.e., 100-90 (A range), 90-80 (B range), 80-70 (C range) and 70-0 (D&F range).
3) Predict the grades of all classmates in course C in GA_i via the student-to-student-based collaborative filtering.
4) Recommend personalized three types of peers for GA_i based on the PGi range and all classmates' predicted grade ranges in GA_i,
   - As potentially more capable peers: Classmates whose predicted grade ranges are above (better than) the PG_i range,

- As potentially similar peers: Classmates whose predicted grade ranges are the same as the PG_i range, and
- As potentially less capable peers: Classmates whose predicted grade ranges are below (worse than) the PG_i range.

Starting from the beginning time of a semester T_1, the prediction and recommendation is done continuously and progressively throughout the semester for each learning time and learning assessment. The prediction and recommendation can be further fine-grained by refining a graded assessment GA_i into a set of sub-assessments and their corresponding sub-learning topics, materials, and activities and by incorporating fine-grained grades and predicting the sub-assessment grades.

3. Conclusion and Future Work

We present a collaborative filtering-based in-course fine-grained progressive performance prediction and predicted performance-based recommendation system for supporting personalized learning within a course. Throughout the entire course, this prediction and recommendation system progressively helps individual students prepare and do better in the course assessments such as homework assignments, quizzes and exams and eventually succeed in the course as a useful personalized learning supporting tool. Our recommendations are based on the predicted grades and thus can be used complementary with the actual grade-based Mastery Paths feature in Canvas.

As future work, we plan to conduct quantitative experimental evaluation using real course data for the efficacy of the proposed recommendations as a personalized in-course learning supporting tool. We will explore applying the proposed predicted performance-based recommendation to a learning management system like Canvas.

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Providing Adaptive User Interfaces in Deviceless Learning Environments

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Abstract: While smart devices such as smartphones and tablets have become indispensable in educational settings, many studies have mentioned related issues such as significant operational costs and low pedagogical effects. Additionally, the problem of inadequate area of students' desk that results in no vacant desk space to place a smart device in addition to learning materials on the desk, that makes it difficult to utilize IT in educational settings, is highly relevant to current times. Consequently, to realize deviceless learning environments, the author of this paper designed "Followable Learning Environment (FLE)". Because the mechanism of FLE is similar to projection-based AR techniques, it can freely control the size and shape of projected user interfaces (UIs). This paper presents methods of detecting the area of blank space onto a student's desk and project UIs that adapt size and shape into the space.

Keywords: Learning Environments, Adaptive UI, Projection-Based AR, One-to-One Computing

1. Introduction

The use of smart devices, such as smartphones and tablets, has become indispensable in educational settings. However, many challenges have arisen to their use, such as operational costs and imprecise pedagogical effects. It is important to ensure proper pedagogical effects and to meet the challenges of using smart devices as a pedagogical tool where they are more of a distraction for the students (Karsenti et al. 2013). When the learning activity does not require a smart device, students must be instructed to turn it off, place it in a bag, and so on, but teachers might hesitate to incorporate devices at all, depending on the instructional model they choose, as the process of restricting their use can impair their convenience (Roblin et al. 2018). Further, a school environment in which students' desks are narrow may lead teachers to hesitate to use smart devices in class, as the students may not have sufficient space for their smart devices where other teaching materials are also necessary to use. This study brings a novel method to bear on these problems to promote utilization IT in educational settings.

2. Methods

2.1.1 The Concept of Deviceless Learning Environment

The author previously proposed a deviceless learning environment called the followable learning environment (FLE) (Mizutani 2019). An FLE detects the arrangement of the students' desks and gestures with the use of sensors located on the ceiling and projects user interfaces (UIs) on each student's desk, using the partial area of a projector placed on the ceiling of the classroom (Figure 1). While the concept of this approach is fundamentally the same of projection-based AR techniques, FLE is distinguished by projecting one UI in the partial area of one projector (Figure 2). Using this area, one projector can project multiple UIs for each student at the same time. Moreover, FLE can detect a desk layout, can adaptively project UIs with adjusted angles or layout sizes (Figure 3). Theoretically, using FLE, several large UIs and personal UIs can be projected at the same time on the area provided by adjoining desks. Hence, FLE can easily realize collaborative environments.

Increasing the number of sensors and projectors, it is possible to provide UIs to the entire classroom. As this approach does not require individual devices, students do not need to be prepared for each student. An application instance of UI, which is projected on the desks, is executed on the FLE system, similar to a thin client system. It is to be expected that this method can reduce management costs relative to the use of smart devices.

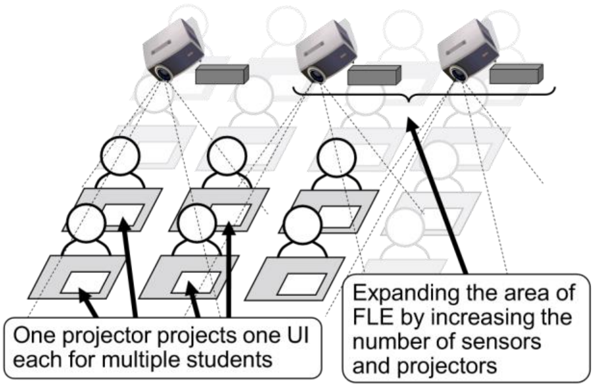


Figure 1. Concept of the followable learning environment.

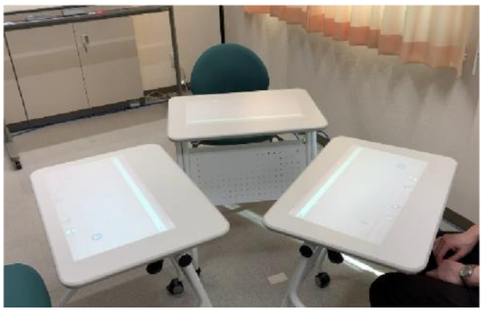


Figure 2. An example of UI projection for three desks separately, using one projector & one sensor.

Figure 3. An example of the UI projection for a group of four desks.

2.1.2 A Method of Providing Adaptive UI in the FLE

2.1.3 The Purpose of Adaptive UI

Students' desks in Japan are often relatively small. In a typical Japanese primary school, a desk is approximately 600-mm wide and 400-mm long. Because the desks are small, there is insufficient space for smart devices in addition to teaching materials such as textbooks, notebooks, reference documents, distributed printouts, and stationery. This makes it difficult to utilize smart devices in conventional classes that require the use of such materials. In the future, these materials might be integrated into smart devices. However, from a pedagogical perspective, the use of physical tools such as notebooks could be superior to smart devices in terms of enhancing students' understanding. This study considers a method of providing adaptive UI with a size and shape that are adjusted to fit the free area on a desk, to respond to this this problem and enable a learning environment where IT can be utilized in conventional classes.

2.1.4 A Method for Blank Space Detection

To detect areas of blank space on a student's desk, the method of this study uses a mask-type object detector, which extracts segmented areas of detected objects in an image. Examples of this detector include Mask R-CNN, a convolutional neural network model. This study uses Mask R-CNN to detect the areas of objects on each desk, such as textbooks, notebooks, and stationery. Because the FLE has a detection function to be for the area of each desk, the area of this space is calculated as the difference between the areas of each desk and the area of each object.

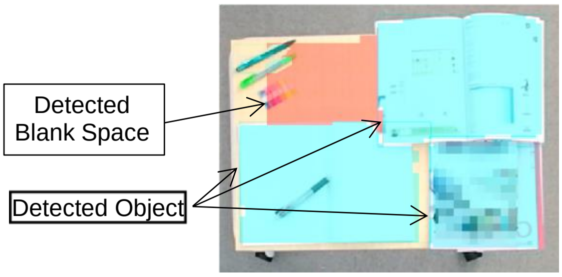
2.1.5 A Method of Projecting Adaptive UI

After the blank space is detected on the desks, adaptive UI is projected, adapting to the size and shape of the blank space area by tree steps as follows: (1) if detected areas are adjacent, they are combined into a single area; (2) a suitable area for UI projection is selected, with its position, square area, and aspect ratio; (3) a UI is projected that is adjusted in size and shape adapted to the selected area. Figure 4 shows an example the result of detecting objects and selected area of blank space on a desk.

3. Developing Prototype System and Consideration

This method was implemented to the prototype system of the FLE. As a model of Mask R-CNN, Inception ResNet V2 1024 × 1024, a pretrained model of TensorFlow Object Detection API, was used. Because the FLE was developed as a.Net Framework application, this model was converted to an ONNX model and implemented on FLE.

Figure 5 shows an example of projected adaptive UI with the prototype system. The adaptive UI of the prototype system is a pseudo UI. In the future, application programs which have adaptive UIs will be implemented such as learning support, CSCL tools and so on. Since the system used a high definition detection model, detecting objects on a desk takes approximately 5 seconds. The precision of object detection is also insufficient. In particular, as the kinds and shapes of the stationary used are various, more sample images are needed to train the model. Resolving these issues is necessary for practical use.



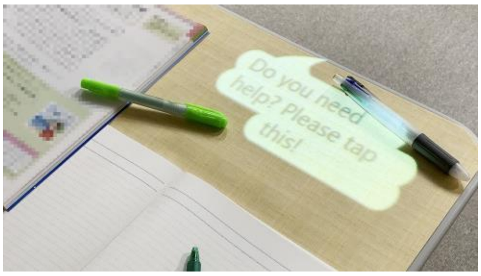


Figure 4. An example detection result on a desk*. *Figure 5.* An example of projected adaptive UI*.

*There is no mosaic of textbooks in the actual images (copyright reason)

4. Conclusions

This paper describes the FLE method and prototype system, developed to provide adaptive UI in a deviceless learning environment. Because UIs are projected in a way that adapts the size and shape to blank space on a desk, the system ameliorates the problem of students' desks being too narrow and enables the increased use of IT in conventional style classes, using teaching materials such as paper-based textbooks, and notebooks.

Acknowledgements

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Educational Assistant Wireframe for the Elderly to Mitigate Urban Climate Health Risks

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Abstract: The climate in urban centers can differ significantly from the immediate surrounding areas; this can pose health risks to the elderly who have spent much of their lives in urban centers and then move to more rural areas for retirement. Therefore, there is a need to develop educational software applications for the elderly that needs to account for their life experiences aside from physiological restrictions. This research created a connected wireframe for an educational assistant to make the elderly aware of the climate differences between their urban and rural residences. To address the difficulty of recruiting vulnerable subjects, especially during the COVID-19 pandemic, we evaluated our wireframe using a combination of heuristic evaluation and a variation of the Delphi process, an expert consensus-building tool typically used for market forecasting.

Keywords: urban climate, healthcare technology, educational technology, human-computer interaction, Delphi process, personal assistant

1. Introduction

Climate change is one of humanity's defining problems since our society's rapid development in the 20th century. Some of the salient observations include global warming or tremendous shifts in weather patterns across continental, regional, and neighborhood scales (Varquez & Kanda, 2018). At the district level, its spatial variability poses location-dependent health risks. For example, projections on urban development in Jakarta conducted using a high-resolution 1-kilometer regional climate modeling have shown that urbanization may have more significant consequences than global climate change scenarios if left unmitigated (Damanto, et al., 2019). Areas that are geographically near can have drastically different climates if they have different degrees of urbanization, such as in the case of city centers and their surrounding suburbs. By the 2050s, greater Jakarta's urban climate change increases the risk of elderly heat-related mortality by as much as 15 times compared to the 2010s (Varquez, et al., 2020).

For similar large metropolitan areas such as Tokyo and its surrounding areas, the above conditions exist and awareness of these should be known to the public. In 2014, 172,000 people moved out from Tokyo city center to these nearby areas such as the relatively rural West Tokyo suburbs and the neighboring prefectures such as Saitama and Kanagawa (Tokyo Metropolitan Government, n.d.). For the elderly who chose to have their careers in Tokyo and retire near the city center where they spent decades living and working, it can be hard to realize that there can be drastically different climates between places that are somewhat close. These unrealized differences can pose serious health risks. A way to make the elderly aware of these health risks is using smartphone applications. In this paper, we explored the process of creating an educational assistant that can help mitigate such climate-related risks.

2. Related Work

Enabling humans to interact with their environment, ensure well-being and health, and foster learning and creativity are just some of the grand challenges in human-computer interaction (Stephanidis, e al., 2019). As such, there is existing work in the same space as we are trying to break through. Examples of this include usability of health applications (Zapata, et al., 2015), and accessibility of the ubiquitous smartphone user interface for the elderly (Salman, et al., 2018). Our work is not just at the intersection of health application and elderly UI but also on adult education.

Eudaimonia, or "true happiness" as found in the expression of human excellence and virtue, is also one of the HCI grand challenges. Basic psychological needs such as autonomy and competence must be respected to achieve this so-called life worth living (Ryan & Deci, 2017). This is especially visible in adult learners: they are self-directed and use their life experiences to learn (Knowles, et al., 2014). As such, for them to be receptive to new learning, they must see the value of it first.

This puts several concerns to light. While existing applications cover our general areas of interest - weather, health, and learning - we are yet to find an application that addresses the vital need to educate the elderly about weather-induced health risks. How can we present this information so that the elderly will decide on their own worth their while? How can we package this information to appeal to the elderly with highly varied competency levels in the subject matter? And finally, how can we impart life-saving knowledge to them that will seem contradictory to what their lifelong experience tells them? To address these concerns, we conceptualized an application that will contain weather forecasting, health tracking, and educational technology to highlight health risks while providing utility to the user.

3. Method

Members of the research team conducted brainstorming on the target application first through exchanges in email and a messaging platform to narrow down the problem intended to be solved and propose potential solutions. A member was assigned to collate the information from the exchanges. The same member then created an outline composed of a list of screens and their intended functionalities based on this information. This outline was subjected to a face-to-face intense brainstorming session where starting points for the wireframe had been decided. The wireframe was designed for smartphones since smartphones are ubiquitous and have the least space availability. Scaling up to larger devices will be easier than scaling down since accessibility by the elderly greatly suffers when user interface (UI) components are too small. A low fidelity connected wireframe, or a set of monochrome linked screen illustrations, was created to enable the evaluators to focus on the application content and interaction instead of the overall look and feel.

Ideally, a UI should empirically be tested by actual users. For our particular use case, the elderly may be a vulnerable population; hence, ethical and health considerations should be given more attention, making too frequent user testing of wireframes relatively impractical. Heuristic evaluation where experts assess a user interface based on established rules may complement user testing. Since we are still in the very early stages, we decided to use heuristic evaluation first. For the heuristics, we started with the 12-item heuristic SMArtphone's uSability Heuristics (SMASH) (Inostroza, et al., 2016) to match our target environment.

Aside from usability on smartphones, we also need to consider whether our proposed system aligns with proper relaying of weather information, has educational value, approachable for our target population, and will not endanger their health. We used the Delphi process to identify important factors to consider during evaluation. Delphi process, or estimate-talk-estimate, is a tool used in marketing decision-making where experts arrive at a consensus through a series of sharing forecasts and refining said forecasts based on the currently available information from other experts.

The Delphi process result is combined with SMASH, including the items that may not apply to the wireframe. Deciding the applicability of each SMASH item is left to the evaluators. For the heuristic evaluation itself, the experts are provided with short explanations and inspect the wireframe. They listed the issues encountered for each heuristic, which is then summarized by the moderator. The heuristic evaluation was done by the same experts who executed the Delphi process. The experts from the areas of elderly healthcare, urban climatology, science communication, and educational technology.

4. Results

It is evident from the heuristic evaluation that a higher fidelity is needed to assess the application definitively at a minimum viable product stage. The difference in expertise areas of our experts was evident, especially during the heuristic evaluation. Each expert was able to raise issues not raised by the other experts. However, since the experts are well-versed in their areas only, evaluating areas they are less familiar with during the heuristic evaluation or giving suggestions for evaluation criteria during the Delphi process has introduced unease in each phase. Briefing and debriefing protocols (e.g., kick-off meeting to introduce team members, discussion sessions to internalize results, etc.) must be established for assurance and expectation clarification.

The wireframe is yet to undergo user testing. Additionally, demographic considerations, such as culture or generation, remain to be investigated. For example, some cultures view daily news consumption, including weather reports, as the norm. Thus, the effect of such a knowledge gap on weather differences between nearby areas may not be as drastic. We also anticipate that this application will require real-time updates to various data providers (e.g., local weather providers, at the very least). Interactions with external sources can introduce other usability issues, such as latency of information updates. As such, evaluation using prototypes with a minimally functional back end is necessary before full development.

Using the Delphi process for HCI research, and the modifications we introduced, is yet to be scrutinized. This new process can enable interdisciplinary teams with different area concentrations to arrive at a consensus on proposed computer-based solutions to human problems. But at the very least, a separate experiment where the entire Delphi process is executed must be considered.

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"Click it, when you need it": On-Demand Feedback for Online Settings

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Abstract: On-demand help is suggested among the means of reinforcing help-seeking behaviors. This paper presents Help-Button, a closed-loop mechanism for Learning Management Systems that provides students a channel for on-demand support requests, and at the same time informs the teachers about students' progress to intervene accordingly. To explore Help-Button usefulness, we conducted a pilot study to document the experience of the teachers and students when using the proposed mechanism. The preliminary results suggested that participants were satisfied with the proposed tool and perceived the integrated functions as useful. Additionally, we gained insights about further enhancements to allow for dynamic interactions among teachers and students.

Keywords: On-demand Help, Online Learning, Automated Feedback, Scaffolding, Support

1. Introduction

Help-seeking, i.e., students' self-efficacy to moderate their own learning process and seek assistance to overcome their inadequacies (Karabenick & Newman, 2013), concerns a key competence of self-regulation both for face-to-face and online learning contexts (Parnes, Kanchewa, Marks, & Schwartz, 2020). Online learning, nevertheless, is often characterised by a high students-teacher ratio and asynchronous communication, that may overwhelm both the help-seekers and the help-providers (Sheridan, 2006) and hinder the acquisition of timely and tailored support (Chounta & Avouris, 2016; Topali et al., 2022). To promote help-seeking in online learning, Wood & Wood (1999) proposed reinforcing opportunities for on-demand help, where students declare their need for receiving support. Previous studies explored the provision of on-demand support to students in different learning contexts. For example, Alavi, Dillenbourg, & Kaplan (2009) suggested two tools aimed to keep the teachers aware during Higher Education courses, where learners could indicate a) the activity they encountered difficulties, b) the intensity of the problem and c) the time spent with the activity. The authors run a pilot study with the preliminary results to suggest the effectiveness of the tools in improving students-to-teacher communication. Patikorn & Heffernan (2020), attempting to scale-up on-demand assistance in online learning, proposed a system that allows teachers to pre-define assistance to several learner problems.

Building on such context, we propose to combine both timely and personalised on-demand support in online learning by implementing a mechanism, named Help-Button, for Learning Management Systems (LMSs). Help-Button permits students to request help and at the same time informs the teachers about the progress and course behaviour of the students who requested help. Following, we present a preliminary user study of Help-Button under the following research question: *What is the perceived experience of the teachers and students when using the suggested mechanism?*

2. Help-Button Overview

Help-Button is implemented as a Moodle plug-in and permits students to request for help by clicking a green help button placed next to a corresponding resource, e.g., activity or content material (Figure 1, upper left). Help-Button offers two interfaces: a teacher interface (Figure 1, upper right) and a student interface (Figure 1, down). The teacher interface includes information about students' help requests (e.g., numbers of requests, students' course activity). The student interface (appearing when clicking Help-Button), consists of an explanation space, where the student can provide details regarding their request, and a response area where predefined, automatic help is given in the form of additional material, brief explanations, hints etc.

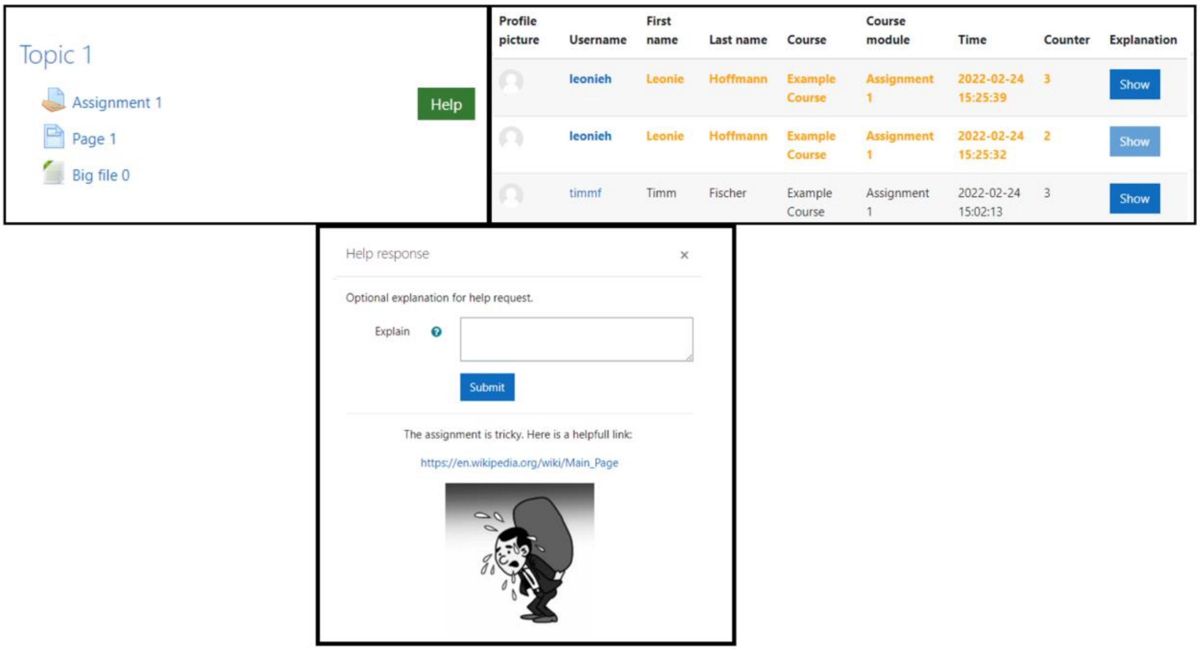

Figure 1. The three main Help-Button interfaces. Upper Left: Overview of the Help-Button in the course. Upper Right: Instructor interface with information related to the help requests. Down: Student interface

3. Method

To test Help-Button, we conducted a preliminary user study with 9 participants (5 students and 4 teachers). We provided the participants with predefined tasks depending on their role (that is, student or teacher) that we asked them to carry out. These tasks involved reviewing help requests and designing support for Help-Button (for participants who acted as teachers) and asking for help using Help-Button (for participants who acted as students). Then, we asked participants to fill out a questionnaire, based on the validated instrument System Usability Scale (SUS) (Brooke, 2013) to gather insights regarding the participants' experience with Help-Button. Specifically, teachers' questionnaire included the 10 SUS items which respondents rated on a 5-point scale (from 1-strongly disagree, to agree 5-strongly) and students' questionnaire included the first four SUS items (since the rest of them did not correspond to students' viewpoint). An open-ended question was delivered both to students and teachers asking about general perceptions and concerns after using Help-Button.

4. Preliminary Results

Regarding usability as measured by SUS, teachers evaluated the Help-Button highly (M= 92.5 out of 100, SD =4), potentially indicating Help-Button´s potential. While SUS requires 5 participants at least for warranting its reliability and we only had 4, the participants' responses to the open-ended questions suggested that they enjoyed the tool and its potential (i.e., "*I think the plug-in is easy to use and very well integrated within Moodle. From my point of view, this is a very important feature that can make the difference*", "*I would say that the plug-in is really fascinating and can be very useful most of the time*"). Similarly, students' ratings suggested willingness to use the tool frequently (M=3.8, SD=0.84), low complexity (M=1.4, SD=0.55), ease of use (M=4.4, SD=0.55) and quick understanding on how the tool works (M=4.6, SD=0.55) and overall confirmed students' satisfaction with Help-Button.

Participants offered further input on possible mechanism enhancements. Among the recommendations we encountered comments about the need to add filtering functionality to facilitate the teacher's interaction with the tool and personalise the offered interventions ("*...the teacher overview list* *would need some filtering or ordering so the list can be filtered considering the type of activity, the name of the user or the number of submissions*", "*If mandatory (auto-reply) is utilised, it should be filtered in some way so that different responses from the teacher can be offered based on the help needed*"). Additionally, a student proposed placing the mechanism inside the activities to avoid interruptions in the learning process.

5. Conclusions

To support the provision of on-demand help in online learning, we developed Help-Button: a mechanism for students to request support and to receive semi-automated feedback. This paper presents a preliminary study about the experience of the teachers and students when using the proposed mechanism. Concretely, Help-Button was examined under two scenarios, from the teacher and student viewpoints. The results of the implementation suggested that the participants were satisfied with Help-Button and perceived it as useful. However, participants proposed further enhancements to achieve dynamic interactions through the mechanism and increase the level of personalization to the provided interventions.

Our findings are indicative due to the preliminary character of the study and the small sample. In the future, we aim to use Help-Button into an authentic course setting and evaluate its impact during the course enactment. Additionally, we are interested in assessing students' engagement applying standardised questionnaires, e.g., the NASA TLX questionnaire (Nasa, 2006), and triangulation.

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The Development and Preliminary Evaluation of an Educational Game for Online Flight Reservation Services That Involves Real Person-NPCs

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Abstract: In the midst of the COVID-19 pandemic, distant learning has become a norm. In this study, a situated learning game "Ticketing Expert" was designed, combining the real person-NPC mechanism to provide a highly realistic travel agency environment and atmosphere. In the game, the real person-NPCs play the customer, which allow the learners to be immersed in the travel agency's ticketing department and simulate the interaction between the ticketing staffs and customers for enhancing learners' ticketing and communication capabilities. The preliminary study investigated the learners' flow state and their acceptance of the game. The results showed that the game-based learning mechanism could effectively enhance the flow of the learners, enabling them to be highly concentrated. And the learners highly agreed with the idea of using the game to help them learn in the ticketing field.

Keywords: Real person-NPCs, educational game, situated learning, Flight reservation services

1. Introduction

As the COVID-19 outbreak that erupted in early 2020 spread around the world, to ensure that learning was not interrupted, education institutions have been forced to adopt distance learning. If an interactive mechanism and situational experience are missing in the design of distance learning, the learner may lack concentration and context, resulting in insufficient learning motivation and anxiety, thus reducing the effectiveness of learning. Paudel (2021) believes that most distance learning leans towards the development of knowledge-based awareness, which means the applied learning environment of practical operational skills is often overlooked. The study by Kailani, Newton, & Pedersen (2019) found that game-based learning develops the students' ability to solve problems and that it has a certain degree of impact on developing the learners' higher-level skills such as decision-making, critical thinking, problem-solving, and collaboration skills (An, 2018). A real person-NPC for game-based learning can provide players with more realistic verbal dialogues and behavioral interactions (Liu et al., 2021). Different from traditional distance learning software, Gather Town provides a platform where people can work, socialize, and learn (McClure and Williams, 2021) and real-world context could serve as situated learning to foster knowledge and learning transfer (Hou & Keng, 2021). This study used Gather Town to develop a flight reservation service educational game (Figure 1), which enabling learners to discuss and interact in a virtual space through the context of customers' pre-booking of flights. The game features video, voice, and messaging for understanding the customer's thoughts and feelings, eventually helping them complete flight ticket reservations. "Ticketing Expert" is an online game designed to present a travel agency's ticketing department on the Gather Town platform for situational flight reservations. In the activity, learners were provided with relevant ticketing service knowledge as a scaffold, and three real person-NPCs with different socio-economic statuses played the role of customers. Learners must look for the most suitable flights according to the requirements of the customers and help customers pre-book special needs (e.g., seat selection or special meals) (Figure 2). According to the responses exchanged in the process of the activity, customers give feedback and encouragement to the learner after the flight booking is completed to reduce the learner's anxiety.

Figure 1 Online Situational Flight Reservation Game

Figure 2 Online Simultaneous Discussion on Collaborative Ticketing

2. Method

After a preliminary test of case analysis was carried out, the participants in this study were six students (1 male and 5 females) from a university in Taiwan. Teams were formed by online registration, with three people in each team Each participant used a personal computer and participated in the flight reservation service activity in their own separate space. The Kiili Flow Scale (2006) translated and revised by Hou & Li (2014) was referred to in this study. The flow scale includes two dimensions: Flow prerequisites and flow experience. All scales were scored according to the Likert scale. The reliability of the flow questionnaire (Cronbach's alpha=0.855) indicated a high degree of internal consistency. In terms of the acceptance of the game by the learner, the technology acceptance scale proposed by Davis (1989) modified by this study was used, which included three dimensions: perceived usefulness, perceived ease-of-use, and game design elements, and the Likert scale was used. The reliability of the game acceptance scale is (Cronbach's alpha=0.967), which has credibility. The learning activity process began with an activity explanation (10 minutes), a pre-test (20 minutes), game tasks (50 minutes), followed by a post-test (20 minutes), and a flow questionnaire (10 minutes).

3. Results and Discussions

"Ticketing Expert" learning objectives are ticketing and communication skills. Table 1 shows the descriptive statistical analysis of the learner's flow state after completing a task that allowing us to know that the learner is proactively engaged in the game. Overall flow (M=3.94, SD=0.36) was significantly above the median of 3 (t=6.42, p<0.001). The average values of all dimensions of flow prerequisites and flow experience were above the median of 3.00. Among these, the average values of the five dimensions of clear goals, action-awareness merging, concentration on the task at hand, loss of sense of time, the transformation of time, and autotelic experience reached 4.00. This indicates that the overall game design mechanism enables the learner to clearly understand the game's objective of the activity and is proactively engaged in the game to complete tasks, achieving a high level of flow experience, further improving the effectiveness of online learning. Table 2 shows the descriptive statistical analysis of the learner's acceptance of the overall acceptance of the game (M=4.56, SD=0.63), (t=6.10, p<0.01). Perceived usefulness, perceived ease-of-use, and game design elements were all significantly above the median of 3. The results indicate that the learner has a highly accepted acceptance of the game design and that the game was not only easy to operate, and it also improved learners' knowledge and application in ticketing.

Table 2. *Descriptive Statistical Analysis of Game Acceptance*

Dimension	***M***	***SD***	***t***	***p***	***ES***
Overall Flow	3.94	0.35	6.415^{***}	0.001	2.62
Flow Prerequisites	3.90	0.45	4.834^{**}	0.005	1.97
Challenge-skill balance	3.75	0.52	3.503^{**}	0.017	1.43
Goals of an activity	4.08	0.58	4.540^{**}	0.006	1.85
Unambiguous Feedback	3.75	0.61	3.000^{*}	0.030	1.22
Sense of Control	3.92	0.66	3.379^{*}	0.020	1.38
Action-awareness Merging	4.00	0.71	3.464^{*}	0.018	1.41

Flow Experience	3.97	0.35	6.761^{***}	0.001	2.76
Concentration	4.08	0.72	3.692^{*}	0.014	1.51
Time distortion	4.17	0.68	4.183^{**}	0.009	1.71
Autotelic experience	4.00	0.79	3.098^{*}	0.027	1.26
Loss of self-consciousness	3.50	0.48	2.739^{*}	0.041	1.12

$^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$

Table 2. *Descriptive Statistical Analysis of Game Acceptance*

Dimension	***M***	***SD***	***t***	***p***	***ES***
Overall Acceptance	4.56	0.63	6.096^{**}	0.002	2.49
Perceived Usefulness	4.71	0.40	10.448^{***}	0.000	4.26
Perceived Ease-of-use	4.50	0.75	4.881^{**}	0.005	1.99
Game Design Elements	4.47	0.76	4.756^{**}	0.005	1.94

$^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$

4. Conclusion

This study developed an online functional training game "Ticketing Expert" based on the operations of a travel agency. The game combines real person-NPCs, situational learning, and cognitive design, allowing learners to complete tasks using online collaboration on the then Gather Town platform. In the game, three real person-NPCs playing the role of customers gave the learner different ticketing information and the real person-NPC's ticketing supervisors played the role of senior employees to help and interact with the learner. Although the learner was playing an online game, they felt as if they were helping customers book their flights at a travel agency. To summarize the above data, the learner flow performance was significantly higher than the median of 3, indicating that the design of this study combined with real person-NPCs enhanced the flow of online learners in the learning process. The acceptance of the game reached higher than 4, while the perceived ease-of-use reached 4.71, showing that the learners highly agree that the game is helpful in the learning of ticketing knowledge. In the future, this study will be carried out in a quasi-experiment design manner, continuing to explore learners' effectiveness compared to the control group (traditional teaching).

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Aqualab: Establishing Validity of an Adventure Game for Middle School Science

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Abstract: In this work-in-progress poster, we will present how a team including game designers, learning scientists, and assessment scientists collaborated on an online adventure game, Aqualab, with the goal of creating a comprehensive long-format game that can be used across multiple classroom sessions to support development science inquiry practices as well as assess different learning pathways within the game. In this work-in-progress poster, we discuss how the team approached design and development of the game to ensure validity of the game, and how we are planning to further investigate validity evidence of the game as a whole.

Keywords: Game-based learning, Science practices, Validity

1. Introduction

As outlined by the U.S. Next Generation Science Standards, performance of science tasks requires both understanding of core content and the ability to use science practices to investigate the world and solve problems (NGSS Lead States, 2013). To support learning of science practices, learners need to be situated in rich and authentic environments in which they can simultaneously and repeatedly engage in science practices to study phenomena (Crawford, 2012). Digital games can address this need, through immersive experiences in which participants can engage in active learning with simulated science environments and tools (Dede & Barab, 2009). Games provide a useful means of teaching complex science concepts in authentic contexts, while adding mediating scaffolds such as expanding or compressing time and perspective (Kamarainen et al., 2015).

Due to these affordances of games and simulations for better science learning, several research projects developed and implemented science games that specifically target science practices (e.g. Whyville, The Radix Endeavor). While these works report benefits of such games and simulations to support science content learning (Li & Tsai, 2013) and better assess science practices (Gobert et al., 2012), yet little is known about how learners can be immersed in rich and authentic narratives mirroring what real scientists do in the wild, and experiment with different identities in the game while honing science practices by solving comprehensive quests/tasks. In this work-in-progress paper, we present the design and development of an educational game called Aqualab, and in particular, how the team is conducting a validation study of the game.

2. Literature on Simulation and Games for Science Inquiry Practices

There have been several educational games and simulations developed to support and assess science inquiry practices of middle and high school students. For example, Radix Endeavor (Rosenheck et al., 2017), is a massively multiplayer-style online game developed by the MIT Education Arcade to engage learners with biological concepts in an alternate world. Players engaged with real-world problems such as medical diagnoses or genetic study of plant species. Epistemic games such as Nephrotex (Chesler et al., 2013) bridge the experience between more play-centric educational games and learning simulations; as a virtual internship, learners authentically participate in disciplinary practices of evaluating design tradeoffs, proposing solutions, and working within a design team. Other simulations have utilized a more open-ended, inquiry-based approach. EcoMOD (Dickes et al., 2019) and EcoMUVE (Metcalf et al., 2018) both provide students with curricular support in the form of modeling tools which assist them in making sense of the virtual environment. Students are able to collect data, conduct experiments, and aggregate their understandings through agent-based models and concept maps respectively. Observing the benefits of situating science practice within the user interactions, we moved to iterate on these prior designs and build an adventure-centric game around practice-based mechanics.

3. Context: Aqualab

In Aqualab, the student plays the role of an ocean-based research scientist on a ship, taking on "jobs" in different aquatic ecosystems in order to investigate questions relating to science phenomena. To date, 35 jobs have been created across four different ecosystems: kelp forests, bayou, coral reef, and the arctic, covering a range of life sciences phenomena, e.g., food webs, competition, photosynthesis, and adaptation. The game focuses on three science practices: experimentation, modeling, and argumentation. For example, there are jobs set in a kelp forest ecosystem in which students collect organisms, conduct experiments, and build models to determine that urchins eat kelp, and if left unchecked, can decimate a kelp forest. However, sea otters, urchins' main predators, can keep the populations balanced to form a healthy kelp forest ecosystem.

For the design of Aqualab, the team conducted a domain modeling analysis to inform game design decisions. The designers consulted with learning and assessment scientists to bring together specifications of tasks and tools related to the target science practices, a range of rich and interesting questions on aquatic phenomena and systems, and fun and engaging game mechanics and interface. The team also manipulated features of the game to vary the difficulty of in-game tasks in two ways: (1) differences in scaffolding of jobs, and (2) opportunities to engage with more advanced tools at deeper levels of complexity as they progress in game challenges.

4. Validity Study

DiCerbo et al. (2017) describe that evidence for validity in game-based learning can be established in both during the design of the game and after the game has been fully developed. There are several design frameworks (e.g. ECgD by Bob Mislevy, Game, Learning, and Assessment mechanics by Jan Plass) that can be used to achieve "validity by design" where the designers have confidence that the game design choices will produce potential evidence for target competencies and learning outcomes as well as embody theories of learning. After the game is developed, multiple approaches, ranging from traditional psychometric techniques to educational data mining practices, can be applied to provide evidence for validity. For example, Kim and Shute (2015) investigated correlation coefficients between the features generated from key performance indicators of Physics Playground and scores generated from external measure of conceptual physics understanding. Similarly, DiCerbo (2014) applied ECD to create two features (time and completion) related to persistence in an online game called Poptropica and conducted Confirmatory Factor Analysis (CFA) using scores based on the 2 features across three tasks. This work-in-progress poster addresses the question: To what extent can Aqualab be considered a valid assessment of science practices and how can we provide external validity evidence? To answer this question, the team pilot-tested Aqualab at a two middle schools in the Northeast U.S. The game was played by 336 students and five teachers for 5-7 (47-minute) class periods. The team administered an external assessment with these students, consisting of six performance-based tasks: two on each of the three science practices (experimentation, modeling, and argumentation). The tasks were adapted from existing valid assessments including the Stanford NGSS Assessment Project (SNAP) and the Trends in International Mathematics and Science Study (TIMSS) grade 8 science assessment.

Our validation study includes the following steps: (1) The team will process the game telemetry data to generate a set of features that the design team intentionally designed to align in-game actions with science practices (e.g., number of jobs completed, difficulty of jobs completed, time playing the game, incorrect choices in argument, number of experiments that the student ran). (2) The team will conduct a series of exploratory data analyses (Tueky, 1977) to examine whether the selected features seem consistent and identify opportunities for additional feature engineering. (3) The team will examine to what extent in-game features account for performance on the external assessment, including investigating correlation coefficients, factor analysis, and regressors such as Random Forest.

5. Discussion

In this work-in-progress poster, we describe the design and development of an educational game called Aqualab, particularly our effort to establish validity evidence for science practices. During the conference, we will present the game and early findings from empirical investigation of validity evidence. We are currently in the analyzing the data from the pilot study. We believe the design and development of Aqualab for the purpose of supporting and measuring science practices presents unique challenges. Thus, illuminating the design and development process, and how the team is balancing game and learning design while ensuring validity evidence, can be valuable for the field of educational games as well as the participants of the ICCE conference.

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Design of an Online Educational Board Game for Membrane Technology Learning

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Abstract: The study developed an online educational game, Membrane Baby, integrating board game and online situated learning. The learners play the role of the Baby Trainer and have to utilize the feed of the 3 attributes of membrane to obtain membrane knowledge and win the game. We investigated learner's learning performance, learning motivation, learning anxiety and flow status. The results revealed that their learning performance has significantly improved, indicating that the game did effectively clarify the learner's misconceptions about Membrane technology. Although the learning motivation increased, there was no significant improvement.

Keywords: Misconception, online educational game, chemical learning, scaffolding, situated learning

1. Introduction

"Misconception" means any concept that differs from the commonly accepted scientific understanding of the term (Mary B. Nakhle, 1992). Moreover, science misconceptions are persistent, resistant to change, and deeply rooted in some concepts. Therefore, it is urgent to prevent or revise misconceptions as early as possible (Soeharto et al., 2019). Membrane technology is an area where the public is prone to misconceptions. It has been widely used in one's daily life, but since it cannot be seen with a naked eye, it is easy for people to ignore this applied technology, which generates relative misconceptions. Digital game-based learning is considered to effectively arouse learner's interest and learning motivation (Abdul Jabbar & Felicia, 2015; Clark et al., 2016), and flow (Sun et al., 2017). Similarly, board games could promote learners' interactive collaboration and learning motivation (Hou & Keng, 2021). Therefore, during the pandemic, this study expects a learning method that combines the mechanism of board games with online synchronization technology to improve learner's interest and motivation and gradually clarify the misconceptions about the knowledge of membrane technology in the game process so that the learners can achieve highly motivating learning experience in popular science. Thus, our research team (Mini Educational Game development group in e-Learning Research Center, National Taiwan University of Science and Technology, NTUSTMEG) developed an online educational game, "Membrane Baby" (Figure 1). A story was applied in the game as situated learning to facilitate the learners to involve in this activity. The learners play the role of the Baby Trainer and have to utilize the feed of the 3 attributes of membrane to obtain membrane knowledge and get the assistance from their peers. The three kinds of feed stand for 3 attributes of Membrane: Water stands for hydrophilic and hydrophobic. Wood stands for transparent and opaque. Fire stands for dense and porous. Furthermore, the learners are free to exchange their feeds for Knowledge Card as cognitive scaffolding and get the relative Membrane knowledge (Figure 2). The learners must answer the Membrane-related knowledge correctly in order to successfully capture the baby and win the game.

Figure 1. Game panel with the route

Figure 2. Knowledge Card and players answering section

2. Method

Participants in this study were 23 university students in Taiwan (11 males, 12 females) and grouped in 5 teams. All the participants joined the game with a personal computer and communicate with their own microphone. The researchers had the same questions of the pretest and posttest, but in different order. The questions were about the misconceptions of Membrane technology we mentioned in the game, including the three attributes, 20 questions in total. We evaluated the learners' flow status by Kilis's flow scale (2006), which was translated and revised by Hou, & Li (2014). The flow scale includes 2 dimensions, namely the flow antecedent and flow experience. All scales were scored on a five-point Likert scale. The reliability of the flow questionnaire (Cronbach's alpha=0.952) showed high internal consistency. Also, we explored the learners' anxiety by Krashen's Affective Filter Hypothesis (1981;1987), and the reliability of the anxiety questionnaire was 0.796 (Cronbach's α=0.796). Moreover, the learners' motivation was adapted by Pekrun's AEQ (2005), and the reliability of the motivation questionnaire was 0.786 (Cronbach's α=0.786). The procedure of the study was as follow: Pretest for 20 minutes, game for 60 minutes and posttest, learning motivation questionnaire, learning anxiety questionnaire and flow questionnaire for 20 minutes.

3. Results and Discussions

For learning performance, a Wilcoxon signed rank test was used to compare the results of learning performance between the pretest and posttest. The results showed there was a significant difference in the score for the pre-test and post-test (Z=-2.14, p<0.05) (see Table 1), and it suggested that learners' misconceptions of Membrane had been better corrected through the game. For learning motivation, a One-sample Wilcoxon Test was used. The motivation before the activity (M=4.26), during the activity (M=4.48) and after the activity (M=4.52) (see Table 2) were all above the median (the median in a five-point scale =3). The result showed that although there was no significant difference among the steps (p>0.05), the leaners had high motivation during the game. For learning anxiety, a one-sample Wilcoxon signed rank Test was conducted, (M=2.18) (see Table 2), it was significantly lower than median (the median in a five–point scale=3) (t=-5.214, p<.000), and it suggested that learners didn't feel anxious during the game. As for the flow, a one-sample Wilcoxon Test was performed, the overall flow score (M=4.25), flow antecedent sub-dimension (M=4.19), and flow experience sub-dimension (M=4.31) were significant all above the median (the median in a five-point scale =3) (t=9.945, p<.000) (see Table 2). The results indicated that learners were deeply involved in the game.

Table 1. *The mean and standard deviation of learning performance*

	M	SD	Z
pre-test	58.48	15.18	-2.14^{*}
post-test	64.57	11.77	

$^{*}p < .05$

Table 2. *The mean and standard deviation of learning motivation, learning anxiety and flow state*

	M	SD
Step 1 (before the activity)	4.26	1.05
Step 2 (during the activity)	4.48	0.73
Step 3 (after the activity)	4.52	0.67
Anxiety	2.18	0.75
Flow antecedents	4.19	0.70
Flow experience	4.31	0.55
Overall Flow	4.25	0.61

4. Conclusion

The study developed an online educational game, Membrane Baby, integrating board game and online synchronization technology with situated learning and scaffolding, trying to correct learners' misconceptions of Membrane technology in a fun way under the COVID-19. The results showed that the game can be helpful for learners to identify the 3 attributes of Membrane and also to correct the relative misconceptions in their daily life. The results of high motivation, low anxiety and high flow status also showed a high level of learning experience. It indicated that an online educational game integrated with board game mechanism and synchronization technology can be an effective way in promoting learners' learning performance. This game is suitable for students at 7^{th} grade or higher and interested in applied science. Future study would employ different domain knowledge to compare the effectiveness of this game and continue to correct the misconceptions happened in our daily life.

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The Development and Preliminary Evaluation of a Mobile Game for Pattern Recognition Learning

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Abstract: As information technology has become an important aspect of human society, Computational Thinking (CT) has become increasingly emphasized. Among them, pattern recognition is a critical skill in CT, and it is also a key ability in mathematics and STEM. In this study, a mobile game "Guess My Rule" was developed to foster pattern recognition skills, which combined with algebraic thinking in mathematics, allowing learners to develop pattern prediction skills in a code-solving scenario. This preliminary study investigated the learners' flow state, motivation, and anxiety during the game. Descriptive statistical analysis revealed that the participants' flow state and motivation in “Guess My Rule” were significantly higher than the median and anxiety was significantly lower than the median, indicating that the design of the game had a positive effect on learners to engage in pattern recognition.

Keywords: computational thinking, pattern recognition, mobile education games

1. Introduction

Computational Thinking (CT) has become increasingly emphasized, and many countries have been integrating CT into their curricula (Heintz et al., 2016). Although computer programming can be used as a framework for learning CT, CT skills are not the same as programming skills (Rodríguez del Rey et al., 2020). Learners may also develop related concepts of CT (e.g., pattern recognition, abstraction, algorithms) through other forms of teaching initiatives. Pattern recognition is an important skill of CT and is one of the most important competencies for solving a problem that involves finding similarities or patterns in problems to solve more complex ones. (Barron-Estrada et al., 2022). Moreover, pattern recognition is also strongly related to the CT of arithmetic, algebra, and geometry units in mathematics (Ling & Loh, 2021). However, without sufficient motivation and appropriate learning strategies, learning CT can be frustrating for novices, so educators put a lot of effort into finding a way that allows learners to become more engaged in learning CT (Menon et al., 2019). On the other hand, with the adoption of mobile devices into life, many studies have demonstrated the effectiveness of mobile educational games in various disciplines (Chou et al., 2021; Chou et al., 2019). Therefore, in order to establish a more diversified approach to cultivate CT, this study has developed a mobile game that allows learners to build pattern recognition skills by deciphering the codes.

“Guess My Rule" is a code-solving game (Figure 1), developed to help learners cultivate pattern recognition. The code for each level is a series of an equation with three uncertainties: A, B, and C. When a learner submits a set of A, B, and C, the system will give feedback to the learner on whether the value set is valid to bring into the code equation, and the result will be recorded and shown on the screen (Figure 2). If the combination brought into the code equation is not valid, the correct C value for the A and B then be shown in the record section. Each correct set of values would unlock one box of the code. By continuously submitting the correct value set, all the boxes are unlocked, and the learner can proceed to the next level. Besides, “Guess My Rule" also builds a difficulty scale, with a total of 20 levels, divided into 5 levels of difficulty. Through such game mechanics, it is expected that the ability of pattern recognition can be developed via a game approach.

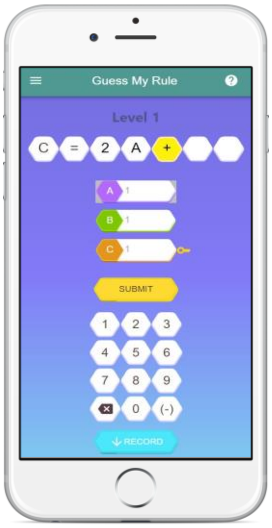

Figure 1. Code-solving Breakout Game

Figure 2. Current Level Answer Records

2. Method

A preliminary pilot study was conducted with 12 participants (10 females and 2 males) who were recruited online from people over the age of 20. Each subject participated in the "Guess My Rule" activity online. The flow scale translated and modified from Kiili (2006) by Hou and Li (2014), was used to explore learners' flow, including two sub-dimensions: flow antecedents and flow experience, with a total of 22 questions. The overall reliability of the flow scale was 0.954 (Cronbach's alpha=0.954), indicating a high degree of internal consistency. To identify the motivation of the participants in the game, the motivation scale was adapted from Keller's (1987) ARCS Motivation Model Scale, which is a five-point Likert scale, with the overall reliability of 0.976 (Cronbach's alpha=0.976) and a series of 32 questions. To assess the anxiety of the participants during the activity, the study adopted the activity anxiety dimension of the Affective Filter Hypothesis scale (Krashen, 1981, Krashen, 1982) with overall reliability of 0.905 (Cronbach's alpha=0.905) and 8 questions. The learning activity procedure in the study started with an activity explanation (10 min), followed by a game task (20 min), and finally, the participants were asked to fill out the Flow, Motivation, and Activity Anxiety questionnaire (15 min).

3. Results and Discussions

Table 1 shows the results of the analysis. It was found that overall flow (M=3.92, SD=0.78) was significantly higher than the 3.00 median (p=.006 < .01), and both dimensions of the flow scale, flow antecedents (M=3.85, SD=0.93) and flow experience (M=4.02, SD=0.77) were also significantly higher than the median, indicating that the game design and experience in general allowed the participants to have clarity on the direction of the task and most of them were engaged in the activity.

Table 1. *Flow, Motivation, and Activity Anxiety Analysis (Wilcoxon Signed-rank Test, median = 3)*

Dimension	M	SD	p
Overall Flow	3.92	0.78	$.006^{**}$
Flow antecedents	3.85	0.93	$.012^{*}$
Flow experience	4.02	0.77	$.005^{**}$
Motivation	3.69	0.86	$.023^{*}$
Activity anxiety	1.80	0.74	$.005^{**}$

$^{*}p <0.05$, $^{**}p <0.01$, $^{***}p <0.001$

The results also showed that the motivation scale (M=3.69, SD=0.86) was significantly higher than the median of 3.00 (p=.023 <.05), indicating that the game activities were well presented and motivated the subjects. The statistical analysis of activity anxiety revealed that subjects' anxiety (M=1.8, SD=0.74) was significantly lower than the median of 3.00 (p=.005<.01), suggesting that the mechanism of this game did not induce excessive anxiety in subjects, which is in line with previous studies (Hung et al., 2015; Lin & Hou, 2022). In the 20 minutes of the game mission time, the minimum number of levels completed by the 12 subjects was 0, the maximum was 17, the median was 3, and the average was 4.7, showing that there was a difference in the completion of the game tasks by the 12 subjects.

4. Conclusion

"Guess My Rule" is a game that combines pattern recognition with algebraic thinking and presents it as a web-based game for learners to practice pattern recognition in a code-solving scenario. The statistical analysis above showed that the learners' flow state and motivation were significantly higher than the median, indicating that the design of this game could make the subjects achieve a high degree of flow experience, and the method has a positive impact on their learning motivation. At the same time, the activity anxiety was significantly lower than the median, so it can be seen that the game mechanism of "Guess My Rule" did not cause too much anxiety to the participants. Nevertheless, there was a large gap in the subjects' game accomplishments. This may be due to individual differences in sensitivity to numbers and regularity recognition. In the future, it is expected that scaffolding will be added to the game to assist learners in the development of pattern recognition ability.

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Estimating Activity Conditions of Students in Class by Measuring Leg Movement

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Abstract: In this study, we propose a method for estimating students' activity conditions in a class by measuring their leg movements. Grasping students' activity conditions are important for teachers to adjust the class progress. The optimal progress will improve understanding of the students. However, measuring students' activity conditions in a class is challenging because it may interfere with their studies. Thus, we introduce a method that measures students' leg movement to estimate their activity condition in a class. Consequently, we found that the variation in the leg movement was often peaked at the time of activity switching in an actual class. Meanwhile, the leg movement did not continue to increase as it would increase the students' fatigue. The results that students' activity conditions in a class can be estimated by measuring students' leg movement. We conducted experiments in the actual class and focused on detecting multiple students' activity conditions. Measuring students' activity will enable us to estimate individual activity conditions.

Keywords: Leg movement, classroom sensing, learner's activity

1. Introduction

This study presents a method for estimating students' activity conditions by measuring their leg movements in a class. Most classes at universities in Japan are conducted as a concurrent lesson that has one teacher and many students. Each student has a different activity condition and grasping the lesson under such conditions is ideal for education. However, a concurrent lesson is selected due to efficiency. To solve this problem, we propose a method in which a teacher can grasp students' activity conditions. The system aids teachers in adjusting the class progress by providing integrated information about each students' progress.

Grasping the activity condition should not disturb the regular classes. A previous study has estimated learners' mental fatigue by measuring their leg movement (Aikawa, Asai, & Egi, 2019). They obtained a significant correlation between the number of transitions in a learner's leg posture and the subjective degree of fatigue. Measuring the leg movement does not disturb learners' activity and distract his/her attention. We hypothesize that there is a relationship between students' activity conditions and their leg movement in a class.

2. Related Works

Goldberg et al (2021) estimated students' engagement from classroom videos. Using the proposed manual annotation, they obtained a correlation between students' engagement and visible indicators; for example, students raise a hand and ask questions. Consequently, they found that analyzing classroom videos enables us to estimate students' engagement. However, students' face photography has problems that an invasion of privacy and interfere with concentration.

Another study grasps students' activity conditions by recording their progress with the teaching materials (Shimada, Konomi, & Ogata, 2018). They attempted to visualize students' learning context by recording page numbers read by students and creating a heat map in a class using e-learning and e-books. Using the proposed system, the page numbers that the teacher is explaining and the page numbers that the students are reading are delivered to the teacher. However, the format of materials is restricted to e-learning which requires preorganized teaching materials with an equal amount of content per page. This method cannot be adapted to a wide range of teaching formats without modification.

3. Methods

This study investigates students' activity conditions in a class estimated by measuring their leg movements. Especially, we focus on the time of activity switching. The time of activity switching is the start time and end time of each activity in the class, including multiple activities, such as a lecture, an exercise, and a test. In a class of typical length, some activity switching is intended, such as answering exercises and asking questions, even if the class consists mainly of lectures.

We introduce a leg movement measurement device to measure leg movement. The leg movement measurement device is placed on the backside of a top plate of the desk at which the student studies. It measures the leg movement of the student sitting in the chair from above. Figure 1 shows the installation of the leg movement measurement device.

Figure 1. The leg movement measurement device (left) and installation (right).

The leg movement measurement device comprises a passive infrared ray (PIR) sensor (EKMC2609112K), a single-board microcontroller (Arduino Nano Every), and a single-board computer (Raspberry Pi 4). The sensor and microcontroller are placed on a breadboard. The single-board microcontroller and single-board computer are connected via a USB connection cable.

4. Experiment

4.1 Procedure

An experiment was conducted to measure students' leg movement during classes practically held in a university of science and technology. The measured data were collected after the classes and analyzed all students' data in the same class at once. The experiment was conducted with 34 university students in a total of seven classes. Data could not be collected for some students due to problems, such as the sensor falling from the desk during the experiments. Then, 28 leg movement measurement data, excluding incomplete data, were analyzed. The classes lasted for 90 minutes. Lecture and exercise sections are provided alternatively. The time of switching lectures and exercises in each class was observed and recorded.

4.2 Analysis

The leg movement amount and range are used as indices for analysis. The leg movement amount is defined as the moving standard deviation per minute. The average leg movement amount per class is used in the analysis. The leg movement range is defined as the difference between the maximum and minimum values of the leg movement amount per minute. In this study, we calculated the leg movement range for the average of the leg movement amount.

5. Result

Figure 2 shows the result of the leg movement measurement of five students in a class. The top shows the average amount of leg movements; the bottom shows the leg movement range; the vertical line shows the time of activity switching. The topic of the class is "Various types of dynamic programming," and the main content is about the pointers of the C programming language. Peaks of the leg movement range mean significant changes in leg movements. The more significant changes in leg movement are at the start of class(14:50), 15:05, 15:12, 15:24 and 15:35. When the leg movement change significantly, students might switch their activities.

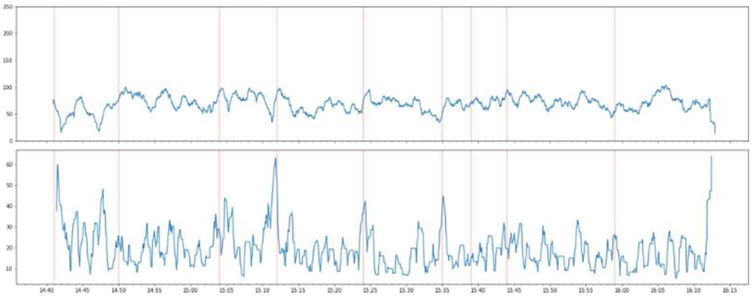

Figure 2. Result of leg movement measurement.

6. Discussion

According to our previous study, we predicted that fatigue would accumulate with learning, and the leg movement amount by students would also increase. The results show that leg movement amount during class did not continue to increase, but rather increased and decreased repeatedly.

The observation of the leg movement range shows that the graph peaked at the time of activity switching. It also shows that there is a larger change than at other times. This suggests that the leg movement range may show a characteristic value at the time of activity switching.

7. Conclusion

In this study, we developed an activity condition estimating system based on students' leg movement measurements in a class. We investigated the activity conditions that can be estimated by analyzing student' leg movement measurements in a class. The experimental result shows that students' leg movement fluctuated more during activity switching than other times. Thus, we can estimate the time of activity switching by measuring the student's leg movement. However, the result of measuring leg movement in class showed that the leg movement was not increasing.

In future studies, we will consider measuring individuals' leg movements related to their activity conditions. We did not follow each students' activities in this study. Therefore, the detail of comparing the leg movement and the activity conditions is necessary.

Acknowledgements

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Design of an AI-powered Seamless Vocabulary Learning for Young Learners

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Abstract: A thriving development direction of digital language learning has been to integrate mobile-based language learning and AI techniques. Nevertheless, few studies focus on investigating the affordances of AI-embedded mobile learning systems in enhancing formal language learning for young learners. This project sets out to explore how AI techniques can be used to promote Chinese language learning for young learners through strengthening learning across contexts. The present paper introduces the ongoing project by focusing on the design and development of an AI-powered seamless Chinese vocabulary learning system for Singapore lower-primary school students, named ARCHe.

Keywords: AI, second language learning, vocabulary learning, seamless learning, primary school

1. Introduction

A thriving development direction of digital language learning has been to integrate mobile-based language learning and AI techniques, such as automatic speech recognition, image recognition, and natural language processing (Li & Lan, 2021). There is a growing acknowledgement of the value of mobile-based language learning from the perspective of social constructivism, that extends language learning beyond the walls of the classroom to daily life. In this sense, the notion of seamless learning, which highlights bridging separate learning contexts and better integrating everyday experiences with formal education, has received a boost in digital language learning (Godwin-Jones, 2018).

Some studies have been conducted to enhance seamless vocabulary learning through the content delivery method via instant messaging (e.g., Li, Cummins, & Deng, 2017). Other studies regarding taking photos or video clips of what is happening in the real world and using these digital resources to help pupils to deepen their understanding of vocabulary learned in class, and bridge formal learning with everyday living experiences (e.g., Ogata et al., 2015). Moreover, some studies have adopted seamless learning games, and context-aware or ubiquitous user-generated-content systems to enhance English as a foreign language vocabulary learning and learner motivation (e.g., Mouri et al., 2018; Wang & Huang, 2017). There are also few studies on investigating primary school students' seamless learning experiences (e.g., Wong, 2016; Song & Ma, 2021). Nevertheless, these studies focus on either on-campus learning or home-based learning but pay little attention to the linkage between them. There remain little research and validated approaches on designing seamless vocabulary for young learners, linking classroom-based learning and home-based learning.

On this premise, we developed an AI-powered seamless vocabulary learning system, named ARCHe. The ARCHe-based learning activities were designed in terms of the Chinese language curriculum for primary schools in Singapore. The proportion of Chinese households in Singapore speaking English as their main language has risen sharply in the past 20 years. Children from English-speaking families increasingly lack the opportunities to use Mandarin in their daily lives. The project set out to explore how AI techniques can be used to promote Chinese language learning for young learners through strengthening learning across contexts, particularly strengthening the link between home-based learning and classroom-based learning. The present paper sough to introduce the design principles of ARCHe and elucidate how AI may help to strengthen the connection.

2. ARCHe Design Principles

2.1 Self-generated contexts

Shen and Xu (2015) provided empirical evidence to support the effectiveness of active learning in classroom vocabulary learning for beginning learners. The findings are consistent with the sociocultural perspectives and holistic ecological approaches applied to language learning, by which effective language learning is characterized by the active and constructive production of thoughtful linguistic artefacts in the settings of authentic learning (Ellis, 2000). Providing students opportunities to create their own artefacts and generate contexts of language learning is an effective approach to learning Chinese characters. Furthermore, in this sense, context does not only determine learning as an external container but is also created by learners (Wen, 2020; 2021).

2.2 Bridging home-based learning and classroom learning

Language educators should encourage learners to find ways to incorporate language learning into their daily lives, using “an adaptive pedagogy that would situate language and culture as lived practice as a central organizing principle" of foreign or second language study (Dubreil &Thorne, 2017, p. 6). That should include connecting learning experiences in the classroom to those outsides, both online and face-to-face. In this project, we aimed to design and support learning experiences that take place. Students’ understanding of the target character or word can be constantly improved during the process. In many cases of seamless learning design, physical things, or artefacts that learners encounter in real-life may play pivotal roles in formal learning. These learning artefacts, however, are often neglected by learners and teachers (Coffield, 2000). The ARCHe system design focuses on promoting the generation and constant improvement of students’ created artefacts across contexts.

3. AI-powered ARCHe

The ARCHe system design focuses on promoting the generation and constant improvement of students’ created artifacts as well as the reflection on their experiences. Automatic recommendation was embedded in the system to enrich the contexts of vocabulary use in classrooms. For instance, while using the system at home, students are required to find materials in their life and generate the target character-related creations, such as picture taking and sentence making via text input or voice recording. After that, students could review not only all personal learning logs, but also related artifacts generated by others and recommended by the system. The generated sentences are evaluated jointly by the system and their teachers.

After that, in the classroom activity, students are assigned into small groups and label the point that they are interested in with the target Chinese character/word in the provided scenario pictures. During the process, students can use the sentences they generated previously and attach them to the new scenarios, they are also encouraged to refine or create new sentences based on the recommended artifacts. Students’ understanding of the target character/word can be constantly improved during the process.

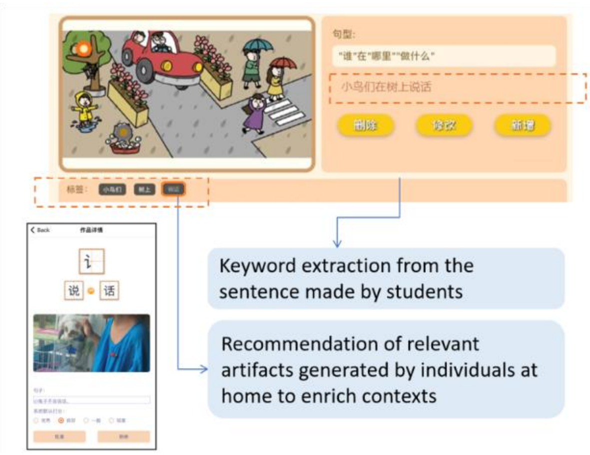

Figure 1. Automatic recommendation to bridge home-based learning and classroom-based learning and enrich the contexts of vocabulary use

Figure 1 shows an example. “Birds are talking on the tree.” was the sentence made by a group. “Birds”, “on the tree” and “talking”, these keywords of the sentence were segmented and extracted automatically. As the keyword “talking” has been used in students’ home-based learning activities, the corresponding artifact was recommended by the system. Then students can decide by themselves if they would like to expand or refine their group sentence based on the recommended sentence or not. The recommended artifacts not only provide students with sentence examples, but also enrich the context in which the target word can be used. The more actively students participate in the home-based learning activities, the more artifacts would be created, and subsequentially, more relevant artifacts will be recommended in the classroom-based activity to promote learning engagement.

4. Conclusion and Future Direction

This is an ongoing project. The ARCHe has been piloted in 6 classes of primary 2 students in three schools in Singapore. According to our preliminary observations, though the seamless learning approach was integrated into ARCHe system design, and the use of AI aimed to promote learning across multiple contexts, teachers still play an essential role in implementing the system. Teachers need supportive training beyond technical training and pedagogical training about seamless learning. Training on useful strategies for enacting collaborative learning in classrooms and engaging young learners in home-based learning might be more important. Our next study will pay more attention to the ARCHe system affordances, how teachers use them, and what kind of training should be provided.

Acknowledgements

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Curriculum Design System Based on AR Glasses for Interest-Driven Learning

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Abstract: In the context of the Fourth Industrial Revolution, emerging technologies have been applied in the field of education more frequently, including Augmented Reality (AR) technology. However, many teachers in China find it a challenge to use AR technology to create specific courses. This may be due to their lack of experience in integrating AR materials curriculum to create an interesting AR course. In this paper, our research group has defined a curriculum design system based on AR glasses and has proposed the process for creating an interest-driven lesson based on Interest Driven Creator (IDC) theory.

Keywords: AR, interest-driven learning, curriculum design

1. Introduction

Presently, with the rapid development of information technology, all kinds of new technologies are springing up and developing. It has always been the focus on how to use these technologies to better promote teaching reform in education. Augmented reality technology, an emerging technology, has also received great attention from researchers in the field of education (Pereira, Arezes, Alves & Duarte, 2019).

Many studies have shown that the application of AR technology in education has numerous advantages such as enhancing students' participation and interest in learning. (Södervik, Katajavuori, Kapp, Laurén, Aejmelaeus & Sivén, 2021; Gutiérrez & Fernández, 2014; Wang, Md Khambari, Wong & Razali, 2021). Augmented reality has become more ingrained in education due to its intuitive nature. Smartphones with cameras allow students to experience AR glasses by using their phones to combine real world and virtual information (Gutiérrez & Fernández, 2014). Compared with smartphones, smart glasses can augment students' vision by allowing them to continuously view information through see-through displays while doing other activities. The device allows students to access information without holding it in their hands. This is because smart glasses can view information by placing it directly in the user's field of vision (Rzayev, Korbely, Maul, Schark, Schwind & Henze, 2020).

In China, although the advantages of the application of AR technology have been an area of concern and recognized by many teachers and researchers, the application of AR technology in teaching encounters significant challenges especially in the design of courses (Qiu, Zheng & Huang, 2021). The design of courses based on AR technology not only requires university teachers to master the relevant augmented reality technology and computer knowledge, but also requires teachers to combine AR materials with specific courses. These high requirements regarding technical and course expertise for teachers make it difficult to develop courses based on AR technology (He, Wang & Zhang, 2018). Although there are available AR teaching courses available on the market, the contents courses are relatively fixed, thus making it different for teachers to integrate the technology with their specific course needs. Because teachers are the subject-matter expert and know what is best for their teaching, it is imperative for them to be able to develop their own system to suit their needs.

Researchers in the Asian region have found that too much focus has been given on examinations, causing lack of interest in learning (Chan et al., 2018). As an effort to combat this problem, Wang et al. (2021) have used gamified AR mobile apps to design an English course at a Vocational College to trigger students' interest in learning, this study aims to conduct a similar approach which is to develop a system that can help teachers design AR glasses courses that could trigger interest among students.

2. The architecture of the system based on AR glasses

The system is mainly composed of two modules and AR glasses (Figure 1). The first module is a back-end module for teachers; it mainly includes the editing field, saving field and material pool. Teachers can edit the recognition content of AR glasses and the performance after recognition by importing their own course materials including videos, audio, images and 3D objects into the material pool or using all kinds of course materials in the material pool directly. The editing server supports these editing functions, and the course materials are stored on the object storage server. The second module is a front-end module for students. This module is developed based on the XR OS SDK, which allows course materials to be converted into augmented reality applications. Students can install the module into their phones and select the courses on their phones and view augment learning materials through AR glasses under the support of a display server.

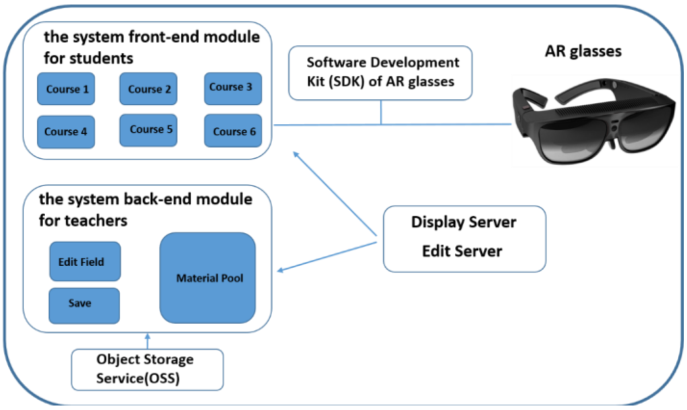

Figure 1. The architecture of the system.

3. The process of designing an interest-driven course

The steps of the design of an interest-driven course by using the system are shown in Figure 2. The interest loop of Interest Driven Creator (IDC) theory proposed by Chan et al. (2018) is utilized to guide the design of the course which involves three steps, namely triggering, immersing, and extending.

Step 1 (triggering): At the beginning of the lesson, teachers focus on triggering students' interest by piquing students' curiosities. This is done by using various types of AR materials. In this process, teachers use different types of AR materials including AR videos, audio, pictures, 3D, and physical objects to provide students with visual, auditory, and tactile perceptions to stimulate students' perceptual curiosity; teachers provide students with rich AR materials so that students can view the rich augmented information in a real environment through AR glasses to actively explore, thus promoting students' interest epistemic curiosity. Teachers provide real objects and scenarios related to the context of what they are learning to stimulate deprived epistemic curiosity as they begin to explore using AR glasses.

Step 2 (immersing): By combining the three key elements of "play", "challenge" and "interaction", teachers make students immersed in learning. In this step, teachers should make full use of the virtual-real function of AR technology and provide students with opportunities to use AR glasses to "play" in real scenes. Meanwhile, teachers should set different types of optional challenges, so that students can gain confidence in the process of completing the challenges; Teachers should pay attention to students' interaction with the real environment by providing discussion opportunities.

Step 3 (extending): In this step, teachers guide students to describe, relate to the real environment and apply knowledge by setting tasks. In this process, teachers set tasks in relevant AR materials. After students learn relevant content, they need to discuss and describe what they have learned, and think and apply what they have learned in combination with the real environment.

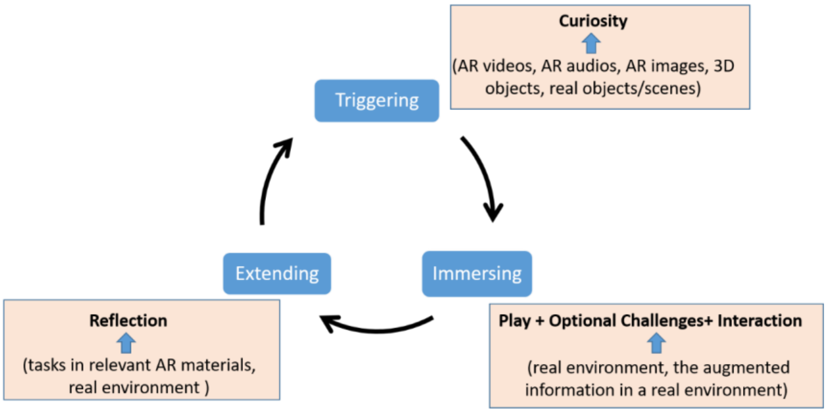

Figure 2. IDC Theory underpinning the course design.

4. Conclusion and Future Work

This study proposed to develop a technology enhanced interest-driven lesson. In a way, it could help teachers design courses that could instill students' interest, even if the teachers know little about the basic technical knowledge of AR. Future studies shall explore on the system's feasibility, students' acceptance and use of the technology as well as its impact on students' interest in learning. The system is currently under development, with follow-up research scheduled to begin in 2023.

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Effects of Binaural Audio on English Vocabulary Learning

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Abstract: The English Picture Dictionary is a dictionary of stock pictures that represent meanings of English words. Following this, our aim was to create an audio repository of stock sounds that similarly represent meanings of English words. To effectively express the meaning of various English words through sound, we used binaural recording technology. For example, when recording the word "fetch," it was represented as a sound movement by moving a dummy microphone head from side to side, while pronouncing the word. This paper reports the results of a comparison between the effects of binaural and monaural audio on the learning of English vocabulary.

Keywords: Binaural recording, computer-assisted language learning, vocabulary learning

1. Introduction

Learning vocabulary is essential for acquiring a second language, such as English. According to the bilingual dual-coding theory (Allan & Desrochers, 1980), vocabulary is retained by forming an association between verbal and non-verbal information. For this reason, the Picture Dictionary (Adelson-Goldstein, 2015) and movies (Zhu et al., 2017) are commonly used in vocabulary learning. The Picture Dictionary is a stock picture dictionary that represents meanings of English words. By following similar lines, our aim was to create an audio version of stock sounds that represent meanings of English words.

With the increasing digitization of learning material, learning formats that use rich audio-visual multimedia content are becoming more common, and are consequently, replacing paper-based material. In second language learning, learning methods that employ smartphones (Dearman et al., 2012) and virtual spaces (Vazquez et al., 2018) are often proposed. EmoTan (Fukushima, 2019) is a learning system that specifically utilizes auditory technology; it employs emotional narration and stories in the learning of English words and utilizes binaural recording technology to create sounds through emotional expressions. Fukushima (2019) demonstrated how the use of EmoTan enhances retention of English words, but the experiment involved two variables that change simultaneously, that is, the presence or absence of an emotional story and binaural recording technology. It did not examine the effect of binaural recording technology alone.

Therefore, this paper focuses on the presence or absence of binaural recording and examines its effect on the learning of English vocabulary. For this, we first categorized English words according to whether they could be represented by binaural recording technology or not. Next, 40 words were selected from the dataset, and their audio content was created in a binaural recording studio by a professional voice actress. Finally, a psychological experiment was conducted on these 40 words, to assess the effect of binaural recording on the retention of English words.

2. Word Selection and Binaural Audio Recording

First, it was necessary to select words whose meanings could be expressed through binaural recording technology. For this purpose, we used a cloud worker service (Amazon Mechanical Turk, Amazon.com Inc.) to classify the words. A total of 12,000 words were classified from the SVL word list (published by ALC PRESS INC), which were considered useful for Japanese learners. For each word, seven workers assessed the suitability of the method. We also used the Common European Framework of Reference for Languages (CEFR), which provides a common basis for the explicit description of objectives, content, and methods for second/foreign language education, to check the vocabulary level of the classified English words. The following question items were designed for workers to judge the words accurately. "Can the meaning of the above word be conveyed using voice, sound effects, sounds made by objects/things, or a combination of these, without the word being spoken out loud? (Our goal is to realize stock sounds/narrations in a binaural recording studio, using the expressive voice of professional voice actors, sound effects, BGMs, and various objects/things)." In addition to this, we confirmed whether the words' prefixes and suffixes encouraged or discouraged the discerning of their meaning or memorization, and if they were at CEFR level B2 or higher, considering that our subjects were high school students.

Of the classified words, 40 English words were selected, for which more than half of the workers had answered "Yes," and binaural audio was recorded for them. Images from the recording are on the left of Figure 1. The motion information in the words was reproduced around a microphone with a dummy head. Some of the words and expressions are shown on the right of Figure 1.

Words	Audio expression
whirl	Circulate: pronounce while circling around the dummy head microphone.
unleash	From bottom to top: pronounce while moving from the bottom of the dummy head microphone to the top.
imminent	Approach: pronounce while approaching the dummy head microphone.
fetch	Left to Right: pronounce while moving to the left or right of the dummy head.
prairie	Facing the wall: pronounce while facing the wall.
aerate	Whispering: pronounce as if whispering near the dummy head microphone

Figure 1 Left: Recording with a dummy head, Right: Examples of words and their expressions

3. Experiment: Effect of Binaural Audio on Retention of English Words

To assess the effect of the presence or absence of binaural audio on retention of English words, we compared the number of words that could be memorized with monaural sound (baseline) vs. binaural sound (proposed). The participants memorized 20 English words for each audio, and attempted a test immediately after memorization, followed by another test a week later. In this manner, we could verify the effects with regard to two aspects: short-term and long-term memory retention. The experiment's detailed procedure and appearance are shown in Figure 2.

The experiment had a within-participants design, with all the participants participating in both conditions (baseline and proposed). There were a total of 20 participants. Of the 20 participants, 15 were male and 5 were female, of an average age of 16.3 years. We confirmed whether all of them had a CEFR score of A2 or lower.

The 40 English words selected were divided across two sets (Set1: blast, dizzy, ascend, flock, bawl, eclipse, crave, dismay, bemoan, mirth, whirl, loony, maraud, bovine, peeve, barrow, suckle, yarn, blast, and prank, Set2: shiver, basin, sniff, buzz, pummel, gust, cajole, sneeze, swig, grotto, implore, honk, snoop, navel, aerate, tumble, rumple, schism, tease, and hornet). We took care to ensure that the word sets did not affect the experiment's results. Specifically, we assigned the participants equally to all combinations of word sets (Set 1 and Set2) and voice conditions (baseline and proposed).

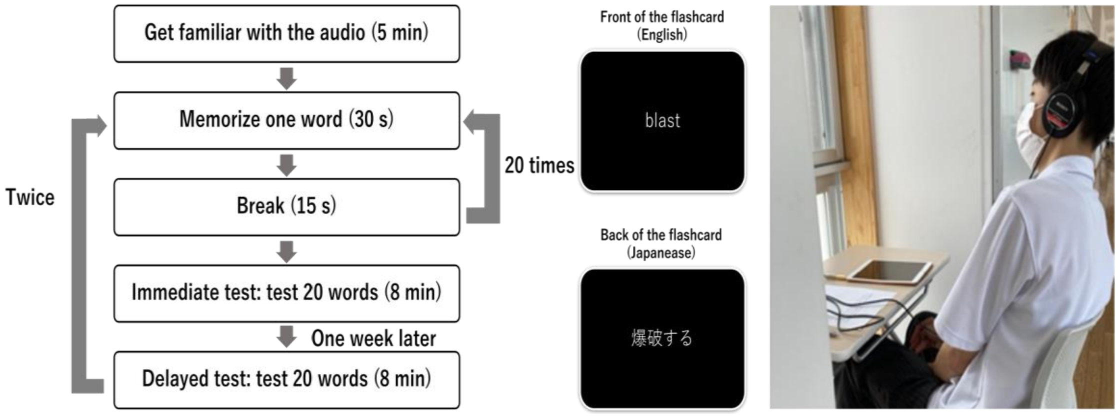

Figure 2 Left: Procedure of the experiment, Right: Image of a participant memorizing

4. Test scoring and the result

The vocabulary test included multiple-choice responses (left of Figure 3). The 20 English words learned were printed on a sheet, on which the Japanese translations were printed at the bottom. The order of the words was shuffled, and participants had to select the correct combination. The percentage of correct responses was calculated based on the number of words answered correctly.

On the right of Figure 3 are the mean scores and standard errors for the monoaural and binaural conditions. We conducted a two-factor ("Monoaural/Binaural" and "Immediately after/One week after") repeated measures ANOVA on the conditions, and the result showed a significant difference in the audio factor ($F(1, 19) = 8.40$, $p<.01$) and test factor ($F(1, 19) = 102.82$, $p<.01$). However, there were no significant differences in the interaction effects ($F(1, 19) = 3.14$, $p<.10$). The results suggest that the score for binaural is superior to that for monoaural, and the score for the test conducted immediately after is superior to that conducted one week after.

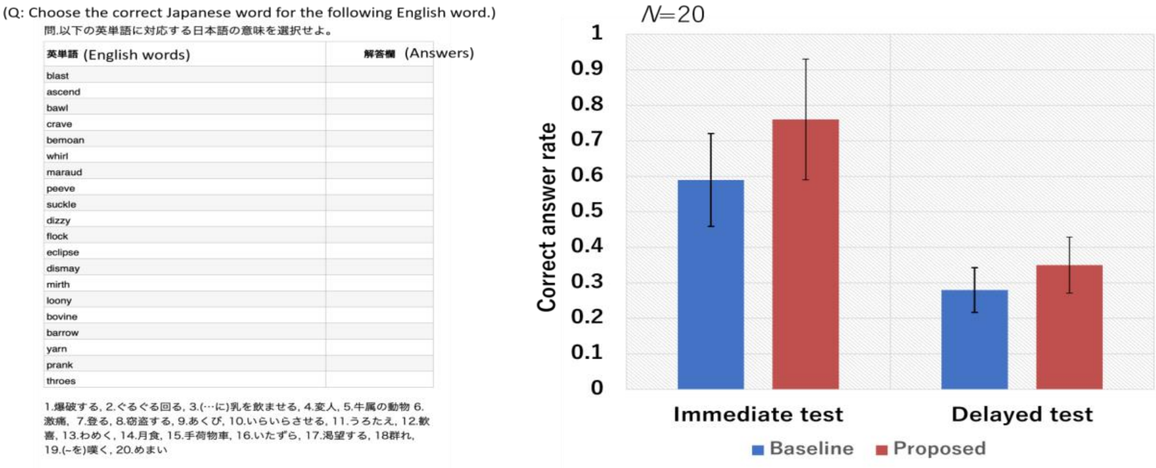

Figure 3 Left: Example of test screen; Right: Mean and standard error of test results

5. Conclusion and Future Work

This paper evaluated the effect of the presence or absence of binaural audio on the learning of English vocabulary. In the future, we shall evaluate the effect of learning over a longer period, as well as develop learning software.

Acknowledgements

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Development of a Chinese Language Learning Content Based on Mixed Reality Technology

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Abstract: This thesis focuses on the design of a Chinese learning system developed using the Unity platform and experiments to test the validity. The validity of the Mixed Reality (MR) learning system was verified by examining the learners' Chinese test levels before and after learning with the MR system, as well as the general affective scale and behavioral engagement and emotional engagement scale for each section of the learning. The results were that learning through the MR system resulted in a significant increase in comprehension and a higher level of positive emotion in the game session with physical participation than in the pronunciation session alone. However, due to the current too small sample size, there was an intentional difference in the overall validity of the negative and emotional engagement. Still, none of the multiple comparisons found a calculated difference.

Keywords: Chinese language learning, Mixed Reality, student engagement

1. Introduction

MR (Mixed Reality, MR) is a technology that adds virtual computer graphics to the real world. And it is a broader category of virtual reality technology (VR) that integrates virtual and natural environments (Maas & Hughes, 2020). Differently from Virtual Reality (VR), which immerses people in a virtual artificially created world (Carmigniani et al., 2011), and Augmented Reality (AR), which presents information by overlaying virtual content on the real world (Azuma, 1997), MR allows users to experience and interact with virtual objects and is highly overlaid with the real and has specific physical properties (Holz et al., 2011). Learning through the MR platform can increase the learner's motivation to learn through the interactive engagement of the body with virtual objects (Lindgren & JohnsonGlenberg, 2013). Moreover, MR technology can amplify the learner's learning experience and provide feedback that cannot be easily obtained in the real world alone (Ohta & Tamura, 1999). Still, there are no studies on Chinese language learning, especially among Japanese learners. Secondly, in recent years, the study mentioned the increasing number of Japanese people learning Chinese (Hirai, 2015). Still, the current Chinese learning, pronunciation, words, and sentences, especially the difficulty of listening and speaking, are the pain points that need to be solved (Liang & Wang, 2022). There are many studies on teaching and learning using multimedia participation to solve related problems because education with multimedia participation can improve learners' engagement, which is called academic engagement or student engagement, or school engagement in the paper (Taylor & Parsons, 2011).

The purpose of this study was to allow learners to learn independently with the MR system installed on HoloLens2 and to validate the effectiveness of the MR system by using general affective scales and engagement scales to measure and test Chinese knowledge comprehension before and after the experiment, respectively.

2. Development

This learning system is developed based on the Unity platform (ver.2019.4.29f1c2). And the system has been developed and integrated using MRTK. The system is divided into six modules in total. This system is designed and integrated based on ARCS theory (Keller, 2016).

The development system's six parts are S0, S1, S2, S3, S4, and S5. S0 communicates the story's background and the MR system's learning objectives with a panda character, "Wang pangpang," who appears in every part of the system and whose function is to provide timely feedback to learners on their learning outcomes. For example, in S0, he is responsible for explaining the course objectives and the story's background, while in S1 to S5, all provide timely feedback on learners' correctness and errors. If correct, the panda will walk up to the learner, perform a random dance move, and give a bilingual "awesome!" If the learner makes a mistake, the panda will say, "What a pity. What about trying again?" The S1 part is to learn the words through the windows system's speech-to-text function, the UI interface; the learner can use the "play" button to play the standard pronunciation, then press the microphone below to follow the pronunciation. After reading, the recognized Chinese words will appear on the left side of the interface and compared with the familiar words; the correct part is green; if wrong, the recognized Chinese words have no color. There is a playback button next to the recording button so that learners can listen to their pronunciation, compare it with the standard pronunciation, and keep learning to imitate it. The UI interface is similar to S1; learners can listen to the standard pronunciation, follow the accent, and see if the pronunciation is correct after recognition. The part without correct pronunciation has no color display, so learners can know which part of it their pronunciation is wrong. The S4 part is to learn the sentence's meaning by interacting with the 3D model in the MR system. The S5 section is a test of learning, where the sequencing of questions is turned into an MR format, and the learner learns from doing rather than relying on their native language. The questions are in MR format, and learners build blocks by placing the right words in the right places and then pressing the last OK button, and the characters on the blocks turn green if they are correct and red if they are wrong, thus learning and trying to make mistakes in sentence grammar.

3. Methods

To validate the effectiveness of the developed MR Chinese learning system, we installed the system in HoloLens2. We conducted a validation experiment with seven students from W university (5 male and 2 female, average age=26.4, SD=5.83). The materials used were the General Affective scale (Ogawa et al., 2000), which consists of three factors, Positive Affect (PA), Negative Affect (NA), and Calmness (CA), with a total of 24 items (8 items for each). The respondents were asked to answer these 24 items using a 4-point scale, with one indicating that they "do not feel at all" and four suggesting that they "feel very much. The Behavioral engagement and Emotional engagement scales of the Student Engagement Scale (Skinner, et al., 2009) asked students to respond subjectively to changes in engagement at each stage of learning. The current experiment consisted of two factors, Emotional engagement (5 items) and Behavioral engagement (4 items). Since there was no discussion and collaboration in this experiment, the question "When I'm in class, I participate in class discussions." in Behavioral Engagement Scale was deleted. The participants were asked to respond to a 4-point scale, with 1 being "not at all applicable" and 4 being "very applicable." And a pre-test and post-test of Chinese knowledge for the participants. The subjects were asked to answer the general mood questionnaire and the engagement questionnaire each time they performed S1 to S5, except for the part of S0 (introduction to the learning objectives and story background). The same Chinese knowledge test paper was administered before and after the experiment to test (Full score of 21 points) the learning outcomes.

4. Results

Figure 1 shows the average scores on the comprehension test. According to the result of the one-way analysis of variance, the main effect indicates a significant difference (F [4,24] = 3.30, p<.05). Multiple comparisons using the Bonferroni method, the results were not found to be substantial. According to the result of the one-way analysis of variance, no significant differences were found in behavioral engagement. A one-way analysis of variance was conducted on the on the comprehension test results of the General Affective scale. For the PA scale, the main effect was significant (*F* [4,24] =3.17, *p*<.05), Multiple comparisons in the Bonferroni method showed that S2 was statistically significantly higher between S2 and S3 (*p*<.05). In the NA scale, the main effect was significant (*F* [4,24] =3.36, *p*<.05), results with multiple comparisons in the Bonferroni method were not found. On the CA scale, the main effect was significant (*F* [4,24] =2.27, *p*<.10), but no results were found for multiple comparisons in the Bonferroni method. The mean of the pre-test scores was 9.71 (standard deviation = 6.36, range 3-20), and the mean of the post-test scores was 19.14 (standard deviation = 1.36, range 17-21). t-test results showed that a significant difference was found between the pre-test and post-test scores (*t* [6] = 3.87 *p*<.01).

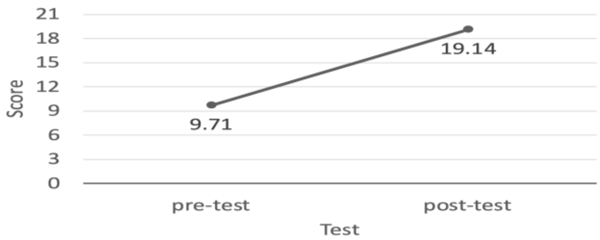

Figure 1. Average points of learners' scores

From the results of the above data analysis, we can currently draw the following conclusions: By using MR Chinese Learning System, learners can learn Chinese effectively. Regarding learners' emotions, positive emotions were significantly higher in the S2 part of the game with physical involvement than in the S3 part, which was purely a pronunciation exercise; therefore, interactive learning games with physical involvement in the MR system helped to increase learners' positive emotions towards learning. Due to the small sample size, there was an overall valid difference in negative affect and emotional engagement. Still, no intentional difference was seen in the individual multiple comparisons, so the study was continued and validated with a larger sample size in subsequent studies. Since all learners were active participants in the experiment this time, the behavioral engagement was high and did not differ significantly. The study will continue in future research in a multi-person classroom.

Acknowledgments

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Motivation Estimation Method for Computer Supported Collaborative Learning Using Tablet Computer

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Abstract: In Computer Supported Collaborative Learning (CSCL), it is difficult to objectively grasp learners' understanding progress and how they contribute to the group learning activities. Therefore, we propose a method to estimate learners' level of understanding and motivation to participate using a tablet computer that can acquire touch operation logs. We define motivation level based on learner's situation. By using a depth sensor to observe learning, learners' movements that are not logged in the touch operation logs are measured, and the motivation level is estimated. An experiment was performed to verify the usefulness of the system. The results of analysis and the opinions of the experts who observed the learning agreed partly. The results of the experiment confirmed the possibilities of the system.

Keywords: CSCL, depth sensor, learner analysis, tablet computer

1. Introduction

We propose a method to estimate learners' understanding and willingness to participate in CSCL by using a tablet that can acquire touch operation logs and information on the work area obtain from a depth sensor. The target is CSCL in which multiple people use a single shared tablet cooperatively. The work area is defined as the combination area on the tablet and the area on the desk where the learner moves his/her hands. By acquiring information on the work area with the depth sensor, it is possible to measure the learner's actions that are not logged in the touch operation log. This enables us to estimate the learner's willingness to learn step by step.

2. Related Work

A method for the automatic evaluation of CSCL that is similar to this study has been proposed (Ruiz et al., 2018). However, the automatic method differs from ours in that it assumes online CSCL and focuses on student message exchanges.

Moreover, the assessment of collaborative learning has been addressed (Strijbos, 2011). It was reported that teachers and students require adequate computer-supported and intelligent tools for monitoring and assessment.

Users have been identified in a tabletop environment by capturing images of the system from the ceiling direction using a depth camera (Masuda, Maekawa, & Namioka, 2016) The advantages of shooting from the ceiling direction are noninterference with the user's activities and low possibility of obstacles between the user and the camera. In this study, we mounted a depth sensor in the ceiling direction to estimate the learner's motivation based on touch operations and hand movements.

3. Research Method

We propose a method for estimating learner motivation based on touch operation logs and work area conditions acquired by a depth sensor during CSCL using a tablet. Learners can directly contribute to learning outcomes through touch operations. In addition, by pointing and hand movements without touch, it can be judged that the user is participating in learning activities such as explanations and instructions. We develop a system that defines the learner's motivation level and estimates the motivation level as shown in Figure 1 and Table 1. There are four motivation-levels (from 0 to 3), wherein the higher the level, the more motivated the learner is.

Table 1. The learner's motivation levels and conditions

Level 0	The situation is that the body cannot be detected in the work area. The learner's hands are not on the desk and the motivation is at the lowest level.
Level 1	The hand is detected in the work area. The learner's hands are on the desk and the motivation is at the second-lowest level.
Level 2	The situation in which a hand is detected over a tablet in the work area. For example, the learner is pointing at the tablet.
Level 3	The situation in which a hand is detected on the tablet and touch operation logs are obtained. The learner is performing operations on the tablet, and the motivation is at the highest level.

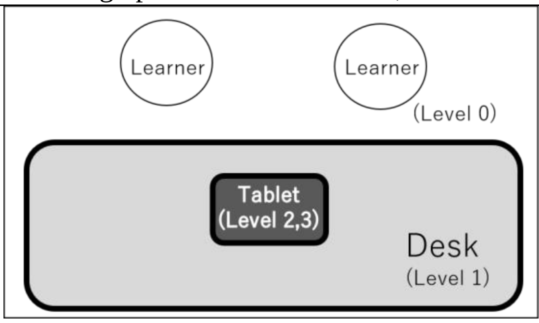

Figure 1. Estimation of motivation level by learner's hand position

A graph is plotted from the changes in motivation level with the elapsed time during CSCL on the horizontal axis and the measured motivation level on the vertical axis. This will not only evaluate the process of CSCL but also can be used to provide support, such as identifying groups with low motivation levels or providing individualized instruction.

4. Analysis in CSCL

We asked three groups of two students per group (Group1-3) to operate tablets collaboratively among members of a group and to think about a solution to a problem for about 40 min. One mathematics learning material on correlation coefficients on a tablet is introduced for first-year students at university of science. The learning material is composed based on a result of discussion by two teachers. The two teachers observe all the sessions. Motivation levels were visually judged and tabulated, averaged over 20s and graphed. An analysis of voice during the study was also performed.

Here we talk about the results of Group 3. The graph of Group3 is shown in Figure 2, and the graph of dialog percentage for group3 is shown in Figure 3.

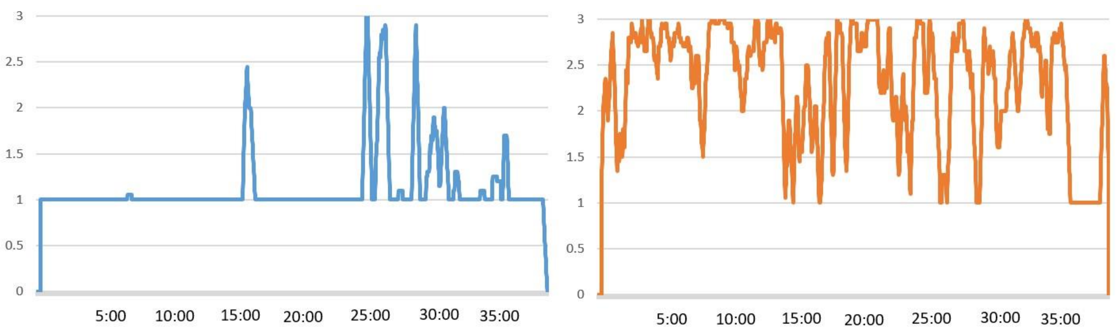

Figure 2. The average motivation levels of Learners A (left) and B (right) in Group 3
(The vertical axis represents level. The horizontal axis represents time)

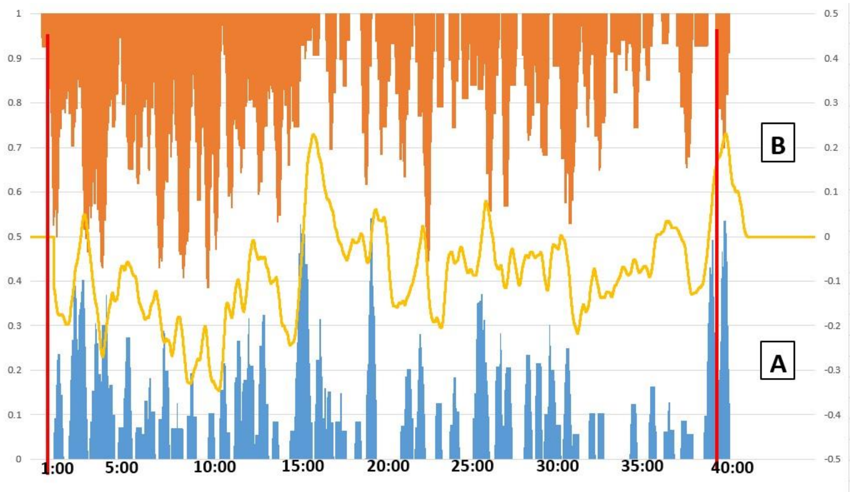

Figure 3. Percentage of dialogue in Group 3 (The vertical axis represents dialog percentage. The horizontal axis represents time)

The level of motivation of Group 3 shows that Learner B's motivation level is high throughout the study. Learner A's motivation level is almost constant at 1 in the first half, but it is high in the second half, mainly when Learner B's motivation level becomes low. It can be inferred that they were alternately operating the tablet. From the dialog analysis, it is estimated that the dialog rate and motivation level of Learner B were both high from the start until 14:00 and that Learner B was leading the study. From 14:00 to 19:00 when Learner A's dialog rate is high, there are points where Learner A's motivation level is momentarily high. However, the motivation level of A is not as high as the dialog rate. The dialog rate in the second half is dominated by Learner A in some cases, but Learner B is dominant in most cases. Learner B's motivation level is also higher in most cases, although Learner A shows a higher value in some cases. For Group 3, the system produced results similar to those from the independent observation by the two teachers who developed the material.

5. Conclusion

The result of analyzing CSCL using tablets were used to establish a method for estimating motivation in CSCL. In the future, we will develop a system that calculates the coordinates of learner's hands by information acquired by the depth sensor and outputs a graph of motivation level in real time.

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Interaction among Undergraduate Students in Graduation Research Seminars in Japan during the COVID-19 Pandemic

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Abstract: Did the COVID-19 pandemic hinder free communication among undergraduate students in seminars and isolate them? In this study, we examine the effects of "online interaction" and "face-to-face interaction" among undergraduate students in seminar activities on their research activities of writing an individual graduation thesis through an interview survey. Using qualitative research methods, we found that the seminar tasks and the seminar system avoided the excessive isolation of the undergraduate students, and that "learning in a community" was established. In addition, while receiving direct advice from senior students facilitated individual research in online interactions, face-to-face interactions strengthened the upward social comparison, that is, the comparisons among peers.

Keywords: Seminar, Undergraduate Research, Online Seminar, COVID-19 pandemic

1. Background and Research Purpose

During the COVID-19 pandemic, the characteristics of the lockdown, such as isolation and reduced social contact, played an important role in higher education in the increase of negative affective symptoms among students (Oliveira et al., 2021). In situations where the students are forced to learn online, face-to-face free communication among them is reduced, which can lead to isolation (Putnam, 2000) and a lack of student interaction and feedback (Bdair, 2021).

In Japanese higher education, graduation research is often set as the major research project in the final stage of the educational program. When the students conduct their undergraduate research, including the graduation research, they usually belong to a "seminar," which is a learning community consisting of supervisors, upperclassmen, and underclassmen. In relation to online learning communities in higher education, Teng et al. (2012) proposed that only through proper instructional design and facilitation, can promote the interaction among the learners, instructors, and content; maximize the strengths of various online resources and tools; and build learning communities.

However, while seminar activities are increasingly moving online owing to the pandemic, it has not yet been studied whether student-student interactions are functioning not only in online seminars but also in face-to-face seminars. In light of this situation, the current study aims to qualitatively clarify the effects of "face-to-face interaction" and "online interaction" in seminar activities on the students' research activities, and to obtain feedback on the learning support for online seminars.

2. Methods

2.1 Participants

The 14 research participants (Table 1) were fourth-year undergraduate students who were conducting their graduation research at the Q Faculty of the P University. They were numbered from A to N in the order of the interviews. The research period was from July 2021 to June 2022, and the interview time for each participant was about 120 minutes. Selection of the participants was based on snowball sampling, while taking diversity into consideration.

The participants in this study belonged to the same seminar for two years. The seminar format was online in the year 2020 and either face-to-face or online in the year 2021, depending on the seminar. There were about 20 undergraduate and master's students in the seminar.

Table 1. *Details of the Participants*

	Student	Gender	Characteristics and Participants of the Seminars
Face to Face	A	Female	The student belongs to a group of six members divided by the content of their research. Senior members of the group, and a supervisor of the other seminar give advice on research.
	B	Male	Biweekly, a supervisor advises the students on individual research.
	C	Male	A supervisor advises on individual research.
	F	Female	Teaching Assistant (TA) graduate students and, as the research progresses, a supervisor give advice on individual research.
	H	Male	A supervisor advises on individual research.
	I	Female	The student belongs to a group of 10 members who are divided according to the content of their research. Senior members of the group and a supervisor provide advice on research.
	J	Male	The student belongs to a group of three members who are divided according to the content of their research. Senior group members of the group and a supervisor give advice on research.
	M	Female	A supervisor and TA graduate students give advice on individual research.
Online	D	Male	The student belongs to a group of eight students divided by research method. Senior members of the group and a supervisor provide advice on research.
	E	Female	The student belongs to a group of three members divided by research method. Senior group members of the group and a supervisor give advice on research.
	G	Male	The student belongs to a group of two members, which is divided according to the research contents. Senior members of the group and a supervisor advises as needed.
	K	Female	A supervisor advises on individual research.
	L	Female	The student belongs to a group of four members who are divided according to the content of their research. Senior group members and a supervisor advises on research.
	N	Female	A supervisor provides individual research advice and guidance outside of the class via Zoom as required.

2.2 Data Analysis

The first author transcribed the data from the interviews with the students and identified the codes based on the verbatim transcripts using qualitative content analysis. To ensure the reliability of the findings obtained, the first author reached a consensus on the codes through discussions with the second author.

3. Results and Discussion

3.1 Online Interactions in the Seminar

Research Advising in Small Groups

As with the face-to-face practice in the seminar, with regard to the students belonging to the small group in the online seminar, there were cases where it was assumed that they would receive guidance from their seniors in the same research topic. The following excerpt reflects this:

(The reason for the transformation of my research) is the advice from my seniors more than from my supervisor. It is not that they directly taught me everything, but there are quite a lot of cases where they suggested me that I should study this kind of knowledge because it might be quite useful (Student D).

In online interactions, receiving direct advice from the senior students facilitated the individual research. This may be due to the fact that they are in the same group and therefore share some research background

3.2 Face to Face Interactions in the Seminar

Common Activities Related to Individual Research

In the laboratory of student M, there was a case in which the common activities were conducted in the seminar room because there was a common task such as "diagramming the relationships between people," in the course of graduation research. The following excerpt reflects this:

When we would assemble in the seminar room, we used to gather almost all of us together, and we would say, "Hey, I'm struggling with this right now." One of us would write out the problem on the whiteboard, and everyone would observe and discuss it. Later, we taught each other how to use Illustrator, since we were all using it quite a bit. (Student M).

The same student M sometimes compared her own work with that of the other seminar students that emerged out of their common activities, and incorporated the valuable points into her own research:

When the other seminar students consulted with the supervisor, they would show him their handwritten analysis of what they had drawn, and he would praise them and say, "Oh, this is good." We would also view the materials that the student had used as a reference and make (relationship charts) together. (Student M).

Research Advising in Small Groups

Since the students belonging to the small groups in the seminar were supposed to be guided by the senior students of the same research theme, the discussion among them was not a priority, but some advice and suggestions were given:

Undergraduates receive guidance from the graduate students. I think it's more like getting comments from the graduate students and making changes, rather than having discussions among the students. (Student I).

Face-to-face interactions strengthened the upward social comparison, that is, the comparisons among peers (Festinger, 1954) in the research activities.

4. Conclusion

The findings indicate that in situations where the students are forced to learn online, the seminar tasks and seminar system avoided excessive isolation (Putnam, 2000) of the undergraduate students, and that "learning in a community" was established. In addition, while receiving direct advice from the senior students facilitated the individual research in the online interactions while the face-to-face interactions strengthened the comparisons among peers. In conclusion, as learning support for online seminar that builds a learning community (Teng et al., 2012) despite COVID-19, the seminar system and preferably face-to-face common activities where the students can compare their work are suggested. The supervisor could also manage the seminar according to the purpose of learning, such as emphasizing face-to-face interactions for the common activities and online interactions for the research supervision.

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Knowledge Building Approach to Teacher Professional Development

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Abstract: This paper describes a work-in-process research project aiming at examining the design of teacher professional development (PD) with knowledge building approach for promoting teachers' epistemology, conception of teaching and learning, and teaching practices. The participants are university teachers who attend the designed PD program. Multiples source data will be collected, including classroom videos and artefacts, online discussion, survey responses, and interview data. We will analyse participants' online discussions and artifacts to understand their knowledge building process. Quantitative analysis will be conducted to examine the change of participants' epistemic beliefs and conceptions about teaching and learning after the program. Correlation and regression analysis will be used to examine how teachers' knowledge building process predict their post epistemic beliefs and conceptions of teaching and learning. Finally, individual interviews will be conducted with teachers to understand how the PD program has influenced their teaching practices. This research will contribute to our understanding of the role of computer supported knowledge building in supporting teacher learning in higher education.

Keywords: Knowledge building; professional development; teacher learning; epistemic beliefs; conceptions of teaching and learning

1. Introduction

This paper describes a work-in-process research project aiming at examining the design of teacher professional development (PD) with knowledge building approach for promoting teachers' epistemology, conceptions of teaching and learning, and teaching practices.

Teacher PD refers to teacher learning after full-time working (Fishman, et al., 2014), and it plays an important role in enhancing teaching and learning in higher institutes. Effective PD can change teachers' beliefs and improve their practices, and ultimately foster students learning (Fishman et al., 2014). PD has been designed with different approaches: some are designed as single sessions; some focus on the social supports for teaching learning, such as building communities of practice (COP), and coaching and mentoring; and some focus on the situated nature of teacher learning within practices, such as using video and other representations of practice as a tools for supporting teacher learning (Fishman, et al., 2014). The current research takes a knowledge building approach to design PD for university teachers. Knowledge building is one of the computer-supported collaborative learning models in education (Bereiter, 2002; Scardamalia & Bereiter, 1994, 2006), focusing on knowledge creation (Paavola & Hakkarainen, 2005). It emphasizes learners working as a community and taking collective cognitive responsibility for idea improvement, much as do actual scientists (Scardamalia, 2002). In knowledge building, learners' collaborative discourse is supported by a computer-supported collaborative learning platform, Knowledge Forum (KF), through which learners pose questions, construct explanations, gather resources or evidence to support/rebut their initial ideas, revise and integrate ideas to improve explanations. We chose the knowledge building approach to PD for the following reasons: 1) Learning sciences research suggests that learning, including teacher learning, is a social and distributed process. knowledge building is a community-based approach, and it could provide teachers with opportunities to work collaboratively with each other (Laferrière, et al., 2007); 2) To level up teachers' capabilities in teaching, there needs to be fundamental changes in teachers' epistemologies and conceptions (Chan & van Aalst, 2006). Previous research suggests that knowledge building has the potential to change learners' epistemic views (Hong, et al., 2016). We propose that knowledge building approach to PD might also improve teachers' epistemic beliefs; 3) Knowledge building focuses on knowledge creation. To better prepare students for this knowledge age where knowledge creation is essential and pervasive, teachers need to learn knowledge creation pedagogies and engage in knowledge creation activities. Designing PD with knowledge building approach could help teachers experience collective knowledge creation processes, so that they can also foster knowledge creation among students.

With knowledge building approach to PD, teachers will be treated as knowledge creators and designers rather than passive learners (O'Sullivan & Deglau, 2006). Different from other community-based approach (e.g., COP) where teachers mainly share their best practices, in knowledge building teachers need to go beyond sharing their best practice, and work collectively to improve their ideas associated with their existing practices and also develop new ones (Fishman, et al., 2014). Teachers will be encouraged to identify and discuss their challenges in teaching, to co-design classroom innovations, and to collaboratively improve the ideas, designs, and practices. This process is usually supported by collaborative KF discourse.

To iterate, the main purpose of this project is to examine the design of PD with a knowledge building approach and its impact on university teachers' epistemic beliefs, conceptions about teaching and learning, and teaching practices. Three research questions will be examined: 1) How do teachers engage in knowledge building during the designed PD program? 2) Do teachers improve their epistemic beliefs and conceptions about teaching and learning after attending the designed PD program? If so, how is their knowledge building process associated with the change? 3) What is the impact of the PD program on teachers' teaching practices?

2. Methods

2.1 Participants and context

We are currently at the stage of preparing data collection. Adopting a convenient sampling approach, we will recruit participants from the university instructors who register for the PD program on knowledge building.

This PD program consists of 3 continuous synchronous sessions (3 hours for each session) spread across one month (week 1, 2, and 4), as well as asynchronous learning between and after sessions. Session, one aims to help participants develop an understanding of KB theory, principles, and technology. During the session, the theories and principles of KB will be introduced and discussed. The KF will be introduced to the participants through a learning by doing process, for instance, participants will be asked to post any questions they have about KB on KF, identify issues or challenges they experience during their teaching, and discuss how the KB approach and KF may help address the issues. After session one, participants will be asked to read their KF notes and continue deepening their discussions. Session two will focus on KB practice and design. Building upon what they will learn from session one and their asynchronous KF discussions, participants will be asked to work in groups to co-design KB practices. After session two, participants will continue their discussion on KF and plan for implementing and adapting KB design in their own classrooms. Session three will focus on practice and reflection. Participants will be asked to work in small groups to improve their group design artifacts and discuss how to adapt the design in their own classrooms. They will also be asked to reflect on their KB practices and KF discussion based on KB principles.

2.2 Data source and analysis

We are taking a case study approach (Yin, 2018) to examine the design of PD and its impact. Multiple data sources, including classroom process (e.g., classroom videos recorded by researchers, participants artefacts and KF notes) and pre- and post-tests data will be collected. Mixed methods will be used to unpack the phenomenon. To address the first research question, we will conduct discourse analysis to examine teachers' discourse on KF to understand how they co-construct understanding and build knowledge together. Coding schemes will be developed to capture the patterns of teachers' discourse moves. Examples of discourse moves include initiate inquiry, sustain inquiry, explanation, and cognitive conflict (Lin & Chan, 2018a). Then the frequency of different types of discourse moves for each teacher will be calculated (Chi, 1997). To address the second research question, paired sample t-test will be used to examine the change of teachers' epistemic beliefs (EBQ, Chan & Elliot, 2004) and conceptions about teaching and learning (TLCQ, Chan & Elliot, 2004) before and after attending the PD program. Correlation and regression analysis will be used to examine how teachers' discourse moves predict their post epistemic beliefs and conceptions of teaching and learning. To address the third research question, we will conduct semi-structured individual interviews with teachers two months after the PD program to understand the impact of the PD on their teaching practices. The interview questions such as the changes they have made in their teaching after attending the PD workshop, and the extent to which they have applied the KB principles (e.g., idea diversity, improvable ideas) in their classroom will be asked. Qualitative analysis of individual interviews will be conducted for theme identification. Both top-down and bottom-up approaches will be employed, whereby priori codes and emerging codes will be used to capture the themes relating to teachers' teaching practices and the impact of the PD on their teaching practices. These interview results will also be triangulated with the survey and process data to explain the findings.

3. Conclusion

This paper describes a work-in-process project focusing on the design of PD with knowledge building approach for promoting university teachers' epistemology, conceptions, and practices. Many existing knowledge building research has been focusing on student learning (e.g., Lee, et al., 2006; Lin & Chan, 2018b; van Aalst & Chan, 2007; Zhang, et al., 2007), comparatively less is known about how knowledge building can be used to design PD among university teachers. This research could contribute to our understanding of the role of knowledge building in supporting teacher learning in higher education. It could also extend the current literature on teaching learning to understand how teachers learn collaboratively through a knowledge building community and how collaborative online discourse might contribute to the change of their epistemology, conception, and practices.

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Evaluating Deep Transfer Learning Models for Assessing Text Readability for ESL Learners

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Abstract: Assessing the readability of texts is a basic task in educating English-as-a-second-language (ESL) learners. As the manual evaluation of readability requires considerable human effort and is costly, methods for automatically assessing readability are needed. In natural language processing, automatic readability assessment is considered a text classification task. Recently, the predictive performance of text classification methods has significantly improved owing to the development of deep transfer learning. In transfer learning text classification, a large unlabeled corpus is used for pre-training, following which fine-tuning with training data, i.e., pairs of texts and their labels manually annotated, is performed. The predictive performance of these methods depends on the pre-trained models and fine-tuning parameters. In previous studies, however, experiments were typically conducted using one pre-trained model with few fixed fine-tuning parameters because testing different models and parameters resulted in technical difficulties, such as insufficient availability of GPU memory. In this study, we compared various pre-trained models on various settings using an NVIDIA A100 unit with 80GiB of GPU memory. We found that using many epochs, considering many tokens, and using large models are key to achieving excellent accuracy.

Keywords: Readability, automatic assessment, natural language processing, second-language learning

1. Introduction

Assessing the readability of texts written by native speakers for second-language learners is essential in language education. For instance, this process is used to select texts in daily language classes. Notably, conducting readability assessments manually is quite costly. To address this limitation, ideally, we must gather reliable human assessors and have them read and evaluate texts. However, as such an undertaking would also be quite costly, we must develop automatic readability assessors using natural language processing (NLP).

Automatic readability assessment (ARA) is considered a text classification process in NLP (Vajjala & Lučić, 2018). The OneStopEnglish dataset (Vajjala & Lučić, 2018) is among the most reliable datasets for benchmarking ARA as a text classification task. In this dataset, professional language teachers read articles acquired from The Guardian newspaper and evaluate their readability for ESL learners.

In recent years, text classification has been an area where deep transfer learning techniques such as Bidirectional Encoder Representations from Transformers (BERT) (Devlin, Chang, Lee, & Toutanova, 2019) have significantly enhanced predictive performance. Further, deep transfer learning techniques have been reported to improve ARA performance (Martinc, Pollak, & Robnik-Šikonja, 2021; Vajjala & Lučić, 2018). Text classification using deep transfer learning techniques can be divided into two stages. First, the model acquires basic patterns, such as the grammar of the text, from a large amount of raw texts written by native speakers. This stage is called *pre-training*. Thereafter, the pre-trained model is trained with manually created training data (pairs of texts and their labels manually annotated) for text classification. This stage is called *fine-tuning*. Various types of pre-trained models have been distributed. However, many previous studies conducted pre-training using only one type of model. For example, Martinc et al. (2021) used only one type of model, namely, “bert-base-uncased.” This tendency may be due to technical limitations such as insufficient GPU memory or training time.

Herein, we report the previously unreported performance of ARAs on the OneStopEnglish dataset, one of the most reliable datasets, with various pre-training models. For pre-training, the SciBERT model pre-trained on a large number of scientific papers (Beltagy, Lo, & Cohan, 2019) and the other models pre-trained on Wikipedia articles were compared. We also compared different fine-tuning parameters that were fixed in previous studies. The results indicated that the SciBERT achieved an accuracy of 0.991, suggesting the effectiveness of using scientific papers for pre-training and the influence of the size of pre-training models.

2. Experiments

We used the OneStopEnglish dataset (Vajjala & Lučić, 2018). The dataset has 567 texts, and each text is annotated with a three-point scale readability of *elementary*, *intermediate*, and *advanced*. We first randomly split the 567 texts into five folds: three folds with 114 texts and two folds with 113 texts. In the experiments, one-fold was used for the test, and the remaining four were used for training and validation. We followed the experiment settings of recent reports (Ehara, 2021; Martinc et al., 2021). Throughout the experiments, we used the Adam optimizer with a learning rate of 0.00001. The *maximum length* is the number of tokens to consider in each text. In other words, each model truncates each text to this number of tokens for classification. BERT can process up to 512 tokens. Although different models work well with different numbers of epochs, most models show best performance within 20 epochs of fine-tuning. Hence, for fair comparison, we report the best accuracy observed in 20 epochs of training. In the four folds, three were used for training and one was used for validation.

Each pre-training model is identified using a name, such as "bert-base-uncased." Because of space limitations, although we cannot show all detailed settings of the pre-training models, we list the identifiers of the models compared: **bert-(base/large)-(cased/uncased)**, **bert-large-(cased/uncased)-whole-word-masking**, and **allenai/scibert_scivocab_(cased/uncased)**. The details of each model can be found at https://huggingface.co/models. Briefly, all models except for SciBERT were pre-trained using 3.3B tokens from Wikipedia and Wikibooks, whereas SciBERT was pre-trained using 3.17B tokens from scientific papers (Beltagy et al., 2019).

Table 1 lists the experimental results. We compared three settings, namely, **Max. 128 tkn., Max. 512 tkn.**, and **Max. 512 tkn. half-train**. **Max. 128 tkn.** uses only the first 128 tokens of each text. **Max. 512 tkn.** uses the first 512 tokens of each text. **Max. 512 tkn. half-train** uses the first 512 tokens of each text, but the number of texts used for training is halved. In Table 1, we have abbreviated **whole-word-masking** in the names as **wwm**.

The average number of epochs corresponding to the best accuracy is written within "(" and ")", and the numbers are rounded as integers. From Table 1, we can easily observe the following novel findings.

1. Three epochs are not sufficient to achieve the best performance in all cells.
2. The maximum length significantly influences the accuracy.
3. The number of texts used for fine-tuning affects accuracy but not as much as the maximum length does.
4. Uncased models tend to achieve better performance than cased models.

Because we could not obtain the test sets used by Martinc et al. (2021), we could not directly compare our results with theirs. However, we confirmed similar scores in their settings. In their study, they fixed the number of epochs to 3 and achieved 0.647 using bert-base-uncased. In our experiments, bert-base-uncased at the third epoch resulted in 0.632. Ehara (2021) reported 0.92 using bert-large-cased-wwm with 128 maximum tokens. We observed 0.850 in this setting because our training/test split was different from the one that Ehara (2021) used. Overall, our best score, 0.991, is likely to have outperformed these previously reported accuracies.

Fine-tuning large models may require a large GPU memory. For example, to train **bert-large-uncased-wwm** with 512 maximum tokens, approximately 73GiB of GPU memory was required. Hence, we conducted all experiments using NVIDIA A100 80GiB. The requirement of a large GPU memory is presumably one of the reasons why this type of comparison has not been extensively conducted.

Table 1. *Best Accuracy Score of Each Method in 20 Epochs*

Model	Max. 128 tkn.	Max. 512 tkn.	Max. 512 tkn. half-train
bert-base-cased	0.850 (19th)	0.982 (14th)	0.947 (20th)
bert-base-uncased	0.912 (16th)	0.956 (12th)	0.938 (17th)
bert-large-cased	0.859 (13th)	0.956 (15th)	0.982 (10th)
bert-large-uncased	0.885 (15th)	0.982 (13th)	0.982 (17th)
bert-large-cased-wwm	0.850 (16th)	0.973 (10th)	0.956 (16th)
bert-large-uncased-wwm	0.903 (20th)	0.982 (6th)	0.947 (14th)
scibert_scivocab_cased	0.780 (4th)	0.982 (8th)	0.956 (11th)
scibert_scivocab_uncased	0.842 (7th)	0.991 (9th)	0.964 (11th)

3. Discussion

Table 1 shows that the use of many epochs, consideration of many tokens, and use of large models are key to achieving excellent accuracy. Further, the results show that the use of SciBERT slightly improves the accuracy for the **Max. 512 tkn.** setting. This implies that SciBERT is suitable for the OneStopEnglish dataset in this setting, which is a novel, previously unreported observation (Ehara, 2021; Martinc et al., 2021). The limitation of our study is that we used the OneStopEnglish dataset for our experiments. Whether SciBERT is also beneficial for other readability datasets remains an open question.

4. Conclusion

We compared previously insufficiently studied experiment settings and identified key parameters that influence the assessment accuracy scores, namely, the maximum length of tokens used in each text, the number of epochs, the number of the data used for fine-tuning, and the selection of the pre-training model. We used one of the most reliable evaluation datasets in this study, and in future, we plan to investigate the other datasets.

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Designing a Professional Development Program on Digital Accessibility and Inclusive Education for Faculty Members

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Abstract: Faculty members play an important role in inclusive higher education. Previous studies have demonstrated the needs to train faculty members on digital accessibility and inclusive education so that they have theoretical understanding and practical know-how knowledge to provide accessible and inclusive digital learning materials and environments to students in higher education. However, literature has also shown a lack of research publications and experience reports in this important area. In this paper, we describe the design of a professional development program for increasing the competence of faculty members on digital accessibility and inclusive education.

Keywords: Professional development, higher education, digital accessibility, inclusive education

1. Introduction

The number of students with disabilities in higher education is increasing (Hauschildt et al., 2021). Digital technology plays an important role in students' everyday lives in higher education. Learning management systems, digital educational materials and various digital tools used in teaching and learning not only benefit students with disabilities, but also pose challenges to them. Inaccessible digital materials and platforms can make it difficult for students to enjoy equitable access and negatively affect their learning outcome. In the time of Covid-19 lockdown and post-Covid, when classroom and oncampus activities are increasingly replaced by online teaching and communications, digital accessibility competence among faculty members and administrative staff are becoming more important to ensure the digital products in higher education are accessible to all students (Chen, 2021).

Studies have shown a lack of awareness and knowledge on digital accessibility among faculty members in higher education (Sanderson et al., 2022; Shinohara, et al., 2018). Literature has also emphasized the needs for and challenges with training offered by the institution for faculty and staff (Marquis et al., 2016). Despite of the willingness to learn, faculty and staff were found in lack of time and resources to gain knowledge about and implement digital accessibility in addition to their already full workload (Sanderson et al., 2022).

A recent systematic literature review (Bong and Chen, 2021) shows that there is a lack of research publications and experience reports concerning raising competence in digital accessibility in higher education. Some higher educational institutions offer training in digital accessibility as a part of their professional development program. However, the training arrangements are diverse in content, pedagogical approach, delivery, and assessment methods. In addition, faculty and staff expressed wishes for personalized training that are customized to their individual needs, preferences, and level of knowledge (Bong and Chen, 2021).

In this paper we describe the design of a professional development program which aims to address some of the existing challenges by providing a flexible and personalized training to a selected number of faculty and administrative staff in each faculty and section, so that they can further help their colleagues to become better in digital accessibility and inclusive education, hence increasing the general competence in the whole institution.

2. Program Design

2.1 Competence Frameworks for Digital Accessibility for Educators

After a critical review of the capacities of the European Framework for the Digital Competence of Educators (DigCompEdu) and the UNESCO ICT Competency Framework for delivering digital accessibility in higher education, Gilligan (2020) highlighted the needs for a digital accessibility competency framework in higher education. He further extended DigCompEdu to include the aspects of digital accessibility such as digital content accessibility knowledge, device knowledge and Universal Design for Learning (UDL) for inclusive course design and delivery. This framework provides a basis for the training contents in our professional development program to increase faculty members' competence in digital accessibility and inclusive education.

Another competence framework developed by Mavrou et al. (2022), the ENTELIS+ Trainers Competence Framework provides a set of competencies for educators, trainers and other stakeholders involved in the education and training for the digital literacy of persons with disabilities and older adults. This framework contains five domains (areas) of competencies: Assessment of Needs, Resource Selection and Use, Inclusive Teaching and Learning, Creating Inclusive Learning Environments, and Promoting Learners' digital competencies. The framework has also identified three types of competencies including knowledge, skills, and attitudes. Although this framework focuses more on assistive technology, our program was inspired by the five domains and three types of competencies in this framework.

2.2 Description of the Program Activities

To achieve a flexible and personalized training while giving participants the opportunities to share experiences, the professional development program has been designed to include the following activities:

1. Recruit participants representing all faculties and sections with two participants from each, so that they can help each other and together help colleagues in their faculties or sections.
2. Individual interview about their background, job responsibilities, experience with and knowledge on digital accessibility and inclusive education, and their expectations of and wishes from the program. We have also asked participants to send in their digital materials so that we can see their level of knowledge and the mistakes they have made.
3. Introduction seminar where all participants meet each other and program team. Participants gain basic knowledge on why, what, and how. Simulations and hands-on exercises are carried out with assistant from master students in digital accessibility. Participants take home materials such as checklists and online learning resources, each assigned a support person who will provide individual follow-up.
4. Each participant learns and practices in their own pace with support from the dedicated support person. In the meantime, they spread the knowledge further to their colleagues.
5. Innovation camp where participants gather and share experiences and address challenges.
6. With the new input gained in the innovation camp, participants go back to their own faculty, learn, and share with support from the support person.
7. Individual interview with participants on their experiences, learning outcome and feedback for further improvement of the program

2.3 Content of the Program and Pedagogical Design

The content of the professional development program is inspired by Gilligan (2020) and Mavrou et al. (2022) and focuses on awareness of laws and regulations and practical know-how knowledge on creating accessible digital learning materials. More specifically, the topics covered in the program include:

- Concepts of digital accessibility and inclusive education
- Related national and international laws, regulations, and standards
- Digital barriers faced by people with disabilities
- How to create accessible digital learning materials
- Tools for assessing accessibility

In addition to presentations, simulation devices such as eyeglasses for different visual impairments and gloves for muscle stiffness and lack of touch sensitivity are used for participants to simulate digital barriers people with disabilities face. Different scenarios are designed for participants to experience temporary disability such as sitting on a noisy and moving bus when trying to watch a lecture video or write a message on mobile phones.

When demonstrating how to create accessible digital learning materials, the analysis of the sentin materials is used as basis for addressing the common mistakes. Hands-on excises are assigned for participants to practice what they have learned.

In the innovation camp, a scenario-based role-play game is designed so that each participant plays a role in the organization of a university, from vice-chancellor and dean to department head and colleague, and discusses good and innovative practices on increasing the overall competences in digital accessibility and inclusive education within the university. Besides individual support, online supporting materials are available to all participants, so that they can access them when needed.

3. Conclusion and Future Work

There have seen considerable interest and efforts among researchers and higher education institutions in providing students with accessible and inclusive learning environments in higher education (Marquis et al., 2016). The professional development program presented in this paper aims to empower educators by providing a customized training and support for each participant, so that they become the experts in their own faculty or section and are equipped with competence to help other colleagues. Further wok will look into the impact of such program on the general competence in digital accessibility and inclusive education in the whole institution and how the program can contribute to the existing competence frameworks in digital accessibility for educators.

All the participants and supporting team are volunteers in this project. Although the program may seem time-consuming for those who provide the training, we are very lucky to be able to recruit master students in digital accessibility who can follow up each participant individually, answering questions, giving advice, and checking the accessibility of materials produced by each participant.

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Teachers' ICT Competency and Technology Leadership Practices for Pedagogical Digital Transformation Initiative: An Empirical Evidence in Klang, Malaysia

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Abstract: In this paper, we investigated the relationship between ICT competency and technology leadership practices located in one of the districts in Selangor, Malaysia. A quantitative correlational study was employed in this research and the respondent was 121 (37.81% response rate) primary school teachers from 35 schools under the jurisdiction of the Ministry of Education, Malaysia. Permission to conduct the research was obtained from the Education Planning and Research Division (EPRD) and the institutional ethics review board, Universiti Putra Malaysia (UPM). Google form was adopted to distribute the survey form and the data was compiled and analyzed using SPSS version 24.0. Pearson correlation analysis revealed significant positive and moderate correlations between ICT competency and technology leadership practices. In summary, ICT competency and technology utilization has become the premise traits for educational stakeholders. With a great challenge in the educational landscape, teachers and school administrators now have an extensive effort to advocate digitalization in education from myriad pedagogical settings.

Keywords: Technology leadership, teacher ICT competency, digitalization

1. Introduction

Information and Communication Technology (ICT) has become an essential and primal factor in the educational system throughout the globe (Omar et al., 2020). ICT integration took place in Malaysian education back in the early 1990s. Since then, the Malaysian Ministry of Education (MOE) has initiated various efforts and intervention programs to provide ICT infrastructure either hardware or software to execute ICT-based instructions effectively (Malaysia, 2013). MOE aims to inculcate 21st-century human capital with creative and critical thinking who can compete with the challenging job market. For this mission, coping with digitalization and the ICT landscape would enhance individual capability and capacities to cope with the current needs of employment.

The utilization of ICT has relatively assisted human beings in devising businesses and the economy. Moreover, the ICT application in the context of education is not new. ICT integration in academia has been introduced in the United States and many European countries as early as the 1960s. Glancing at the global perspectives, voracious efforts and initiatives have been implemented abroad such as the Fatih Project in Turkey, The 2.0 School Program in Spain, Learning Resource Center in Saudi Arabia, U- Taiwan Programs in Taiwan, and 1: 1 Program in the United States (Alenezi, 2017; Banoğlu et al., 2016; Gil-Flores et al., 2017; Wang & Zhou, 2013). The aforementioned projects have proven a success for ICT integration in education in the respective countries. The integration of ICT can be optimized if the school leaders recognize their role as a technology leader to cope with the demanding digital age (Moreina, Rivero & Alonso, 2019). Based on the aforementioned issues, this study aims to examine the relationship between technology leadership practices and teachers ICT competency.

2. Methodology

This study employed a quantitative correlational study at the rural primary school in Klang district involving primary school teachers Based on the record, there are 35 government primary schools categorized as rural in the district of Klang, and the population of the teachers numbered at 1877. The sample size was set at 320 based on Krejie and Morgan's (1970) table. However, only 121 completed forms were received (37.81% of response rate) which beyond researchers controlled. Three set of reminders were sent to respective sample. A multistage sampling was sampling was employed. The first sampling phase involved 35 schools using a cluster sampling. Seven cluster was identified which consisted of five schools. The second phase involved 64 teachers which were selected using a random sampling from each cluster to represent the generalizability of data collection procedure. A set of questionnaires was developed for this study. There were three sections listed in the survey form: demographics, school administrator technology leadership practices, and teachers' ICT competency. The first section contains six items related to the demographic profiles of the respondents: gender, age, type of school, teaching experience, educational level, and involvement in ICT training. The second section was replicated from Leong et. al (2016) and the Principle Technology Leadership Assessment (PTLA) from the International Society for Technology in Education - Standards for Administrators (ISTE, 2009) in determining the technology leadership practices among school administrators.

3. Findings

The result of the correlation analysis informed that teachers' ICT competency and technology leadership practice was found moderately positively correlated at *r* (119) = .571 p<. 01. Among the five dimensions of technological leadership, the systematic improvement had the highest correlation with the value of correlation coefficient, *r* = .605 while the dimension of visionary leadership showed the lowest correlation with the value of correlation coefficient, r = .406.

Table 1. *The relationship between teacher's ICT competency and technology leadership practice*

	Knowledge	Skills	Attitude	Teachers' ICT Competency
Visionary Leadership	.393** .000	.379** .000	.340** .000	.406** .000
Digital Age Learning Culture	.520** .000	.461** .000	.468** .000	.528** .000
Professional Practice Excellence	.505** .000	.468** .000	446** .000	.518** .000
Systematic Improvement	.538** .000	.550** .000	.562** .000	.605** .000
Digital Citizenship	.536** .000	.461** .000	.512** .000	.549** .000
Technology Leadership Practice	.546** .000	506** .000	.512** .000	.571** .000

**. Correlation is significant at the 0.01 level (2-tailed). N= 121

4. Discussion and Conclusion

Teachers' ICT competency is a critical element in determining the effectiveness of ICT integration in teaching and learning processes (Agyei & Voogt, 2011). ICT competency has become an integral part to instill the ICT integration in the educational milieu which subsequently becomes ways of 21st-century teaching and learning techniques and execute plans at the ministry and educational provider levels (MOE, 2012). The ICT competency among teachers can be explained by their willingness to integrate ICT in daily tasks, especially in the teaching and learning settings. The motivated teachers who embrace technology in their daily tasks will eventually increase enthusiasm and self-inquiry to learn and try out new technology (Bordbar, 2010; Hasnuddin et al., 2015; Raman et al., 2019; Varol, 2013). Teachers with a high level of ICT competency especially of those teachers posted in the rural area able to cope with the latest technological developments and are more likely to perform daily tasks in a technological environment, and have an awareness of responsibility, and understand the ethics and trust that must be adhered to when using ICT in performing their duties (Kreijins et al, 2013; Ruuhina, 2018; Zhu & Aslan, 2016).

To summarize, technological readiness will be seen as a premise in teaching, assessment, and delivery of knowledge process. Reflecting on the impact of COVID-19, it is salient to retain educational stakeholders' motivation to acquire and deliver knowledge and educators also do not lose the spirit to impart knowledge to the community of learners. Instead, via technology, educators continue to pour knowledge through an online classroom. The school leader, conversely, needs to deepen their knowledge of new technologies to enculture the ICT integration at school. Thus, the role of technology leaders among school leaders is vital to improving the ICT competencies among school teachers.

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Design Principles of The Educational Recommendation System in Higher Education

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Abstract: The purpose of this study is to identify the needs of instructors and learners for an educational recommendation system (ERS) and develop the design principles of the ERS. We interviewed 17 learners and 4 instructors and surveyed 600 learners in a university. Based on the interviews and surveys, we created an ERS framework and proposed five design principles for educationally desirable recommendations of courses. This study implies that the ERS should be different from recommendation systems for business because the ERS should be responsive to the educational needs of learners as well as their preferences.

Keywords: Artificial intelligence, personalized learning, recommendation system, higher education

1. Introduction

Recommendation systems are much useful to support making a decision when there are a lot of choices. For example, Netflix recommends personalized movies based on customers' viewing records and their evaluation of movies. Although the number of recommendation systems is increasing for business, there is a lack of research on educational recommendation systems (ERS), which have different characteristics from the former. The ERS needs to consider educational purposes and the needs of learners, which are not emphasized in the commercial recommendation systems (George & Lal, 2019; Santos & Boticario, 2015). Preference-based recommendation systems tend to have the problem of filter bubbles, which lead to a biased perspective on a topic, but the ERS should help learners to understand diverse perspectives different from their own. In addition, the ERS should contribute to the improvement of knowledge and skills, focusing on what learners need rather than what they like. The purpose of this study is to explore the ERS design principles for choosing courses. For this purpose, this study not only reviewed previous studies but also analyzed the needs of learners regarding the ERS.

2. Literature Review

In previous studies, the ERS is used mainly for three purposes: course selection support, academic achievement improvement, and career support. First, the ERS can support the selection of courses with personalized recommendation according to learner characteristics, interests, and preferences (Chen et al., 2020; Ng & Linn, 2017). Second, the ERS can recommend a course that allows learners to get higher achievements by predicting their course scores (Bozyiğit et al., 2018). Third, the ERS can help learners to achieve their career goals by recommending courses related to their future careers (Kaur et al., 2019). Although a growing number of studies have developed recommendation systems in the context of higher education, they seldom investigated the influence of the system on learning behaviors and competencies of learners. It is not educationally desirable that learners take only courses that they prefer or can get higher scores. It is necessary to investigate the design principles of the ERS, which can enhance meaningful learning in higher education.

3. Methods

This study interviewed 4 instructors and 17 learners and conducted an online survey (n=600) at a university in South Korea. The interviews were carried out for 60 mins to investigate multiple perspectives on the ERS and to explore learners' experience of choosing a course. The online survey included questions of how learners choose major and liberal art courses, what challenges they encounter in choosing a course, and what functions they need in the ERS. The survey items were developed based on the interviews with instructors and learners, using a 5-point Likert scale (0: strongly disagree, 5: strongly agree). Based on the interviews and surveys, we created five design principles of the ERS.

4. Findings

4.1 Needs Analysis

This study found three themes that should be considered when developing the ERS. First, when choosing a course, learners considered a few criteria: competency development, curriculum, interest, recommendation of friends, career plans, the amount of coursework, and expected grades. Learners considered the development of their competencies as the most important criterion in choosing a major course, whereas they considered their interest most importantly in choosing a liberal art course. Second, learners were likely to have difficulties in choosing a course because there was a lack of information about courses. They also did not have enough opportunities to explore diverse courses. Third, the functions they needed in the ERS included detailed information about courses, course filtering based on learner schedule, search for courses, explanation of recommendation, and so on (see Table 1). In the interviews, learners emphasized that the ERS should explain why a course is recommended to them, but there was a disagreement on whether class reviews of past students should be included in the ERS. The class reviews reflected the interests of learners (e.g., the amount of study, and the possibility of getting high grades), but they were not always educationally meaningful.

Table 1. *Learners' needs of functions in the educational recommendation system*

Function	Major course		Liberal art course	
	M	SD	M	SD
Detailed information of courses	4.2	0.8	4.1	0.9
Course filtering based on learner schedule	4.2	0.9	4.1	0.9
Search for courses	4.0	0.8	4.1	0.9
Explanation of recommendation	4.0	0.9	4.0	0.9
Personalized recommendation	3.9	0.9	4.0	0.8
Connection with courses registration webpage	3.9	0.9	3.9	1.0
Information of past students	3.9	1.1	3.6	1.2
Paths of taking courses	3.9	1.0	3.3	1.1

4.2 Design Principles

The ERS framework is presented in Figure 1. The learners' needs of the ERS are reflected in the "recommendation system" part of Figure 1, and the ERS framework shows how to collect, analyze, and use data to meet the needs of learners on choosing courses. In order to recommend personalized courses, the ERS should collect data of learners and courses from multiple sources of a university and analyze the data using AI-based algorithms such as content-based recommendation algorithm, collaborative filtering-based recommendation algorithm, and recommendation algorithm with the knowledge graph. The ERS should allow learners to search for courses and provide a personalized recommendation of courses based on their competencies, interest, career plan, and curriculum.

This study created five ERS design principles. First, educational data should be safely and efficiently collected and managed in the ERS (e.g., data dam, data pipeline). Second, the recommendation results should be explained so that learners have autonomy in making a decision. Third, the ERS should help learners to develop their competencies in a balanced way through increasing serendipity in recommendation results. Fourth, the ERS should be designed based on learners' experience of exploring, selecting, and registering for courses. Lastly, education experts should participate in the ERS development process, and the ERS should be revised iteratively based on learners' feedback. These principles are necessary for developing a recommendation system that is educationally helpful for learners.

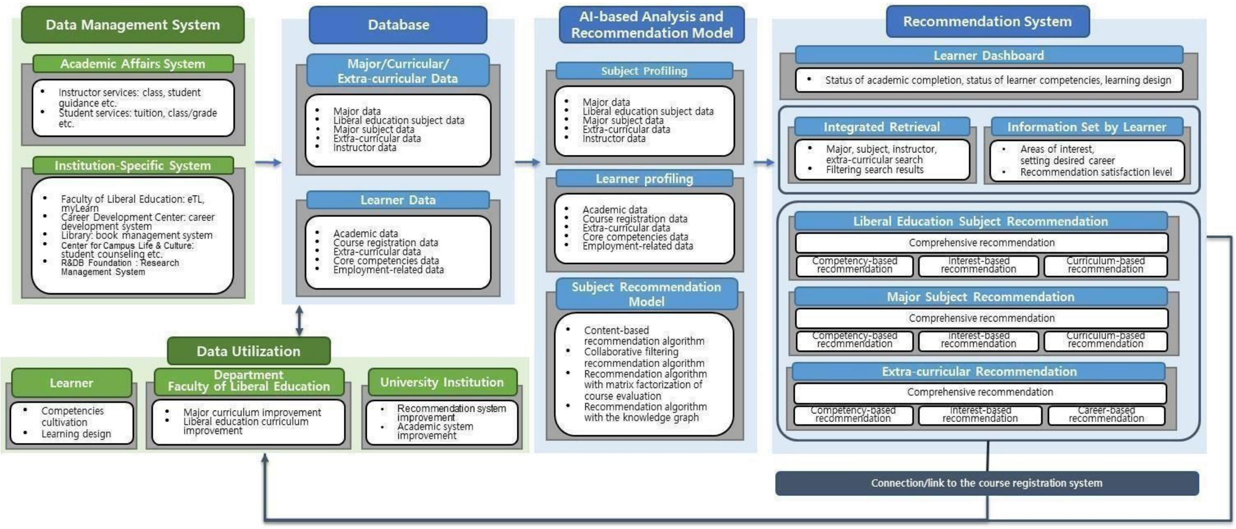

Figure 1. Educational Recommendation System Framework

5. Conclusion

The ERS can contribute to increasing learners' satisfaction with higher education and improving their competencies that are necessary for the future society. Educators should collaborate with computer scientists and data scientists to overcome the problem of filter bubbles and to develop educationally desirable recommendation systems.

This study has a limitation in validating the ERS design principles. Future research is necessary to develop the ERS based on the design principles and iteratively revise them through receiving feedback from learners. Particularly, it is necessary to investigate how to recommend courses based on learners' competencies, which are crucial in education but difficult to assess.

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Handum: Developing a Learning Mobile Game on Health for Philippine Schools

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Abstract: Project Handum was a project by the University of the Philippines and funded by the Department of Science and Technology Philippine Council for Industry, Energy, and Emerging Technology Research and Development (DOST-PCIEERD). There are two primary outputs of this project—an Android mobile phone application called Outbreak Vanguard, which discusses topics in the Department of Education Health curriculum for grade school and high school children through an adventure game, and its accompanying Teacher Portal, a website where teachers can monitor the performance of their students playing the game. This paper describes the theoretical background, software, and content of Project Handum. The Outbreak Vanguard mobile game is available for free on the Google Play store starting August 2022.

Keywords: Games in Education, Health

1. Introduction

Project Handum was a research project created by a team from the University of the Philippines and funded by DOST-PCIEERD. Its two main outputs are the Outbreak Vanguard mobile game and the Outbreak Vanguard Teacher Portal.

In the Outbreak Vanguard mobile game, players explore a world where germs have become clearly visible to everyone. As they explore the world and complete objectives, they learn all about the Prevention and Control of Diseases and Disorders, following the standard curriculum set by the Department of Education of the Philippines.

Teachers may even choose to have the game as part of their Health classes by setting up a class on the Outbreak Vanguard Teacher Portal for their students to join in. As the students play the game, their performance in in-game assessments is sent to the teacher to evaluate how well the students are achieving the learning objectives.

Outbreak Vanguard can be easily integrated into Philippine schools as it follows the official curriculum, in contrast to other learning apps. The team is currently in talks with the Quezon City and Pasig City Local Government Units for the formal adaptation of the Outbreak Vanguard system within the city school system.

The Outbreak Vanguard mobile game is available for free on the Google Play store beginning August 2022. The Outbreak Vanguard Teacher Portal can be accessed at https://www.outbreakvanguard.com.

2. Theoretical Basis

The work of Plass, Homer, and Kinzer (2015) provide four arguments for game-based learning. These are motivation, player engagement, adaptability, and graceful failure.

- ⋆ Motivation is the choice to engage in a task with persistence and intense effort (Garris et al., 2017). Games can be designed to motivate users to keep on playing.
- ⋆ Emotional engagement can occur through a compelling story. A socially engaged player plays the game because their friends play too.
- ⋆ A game can be designed to adapt to the level of the user's cognitive ability, with game levels slowly increasing in difficulty. This allows the learner to quickly go past content they already know and reach learning materials more appropriate to their level.
- ⋆ Finally, games allow for graceful failure as sometimes, failure is necessary for the learning process. Players may be motivated to study more about the topic to pass that game level. Given these design principles, here is an overview of the Outbreak Vanguard system.

3. Outbreak Vanguard Mobile Game and Teacher Portal

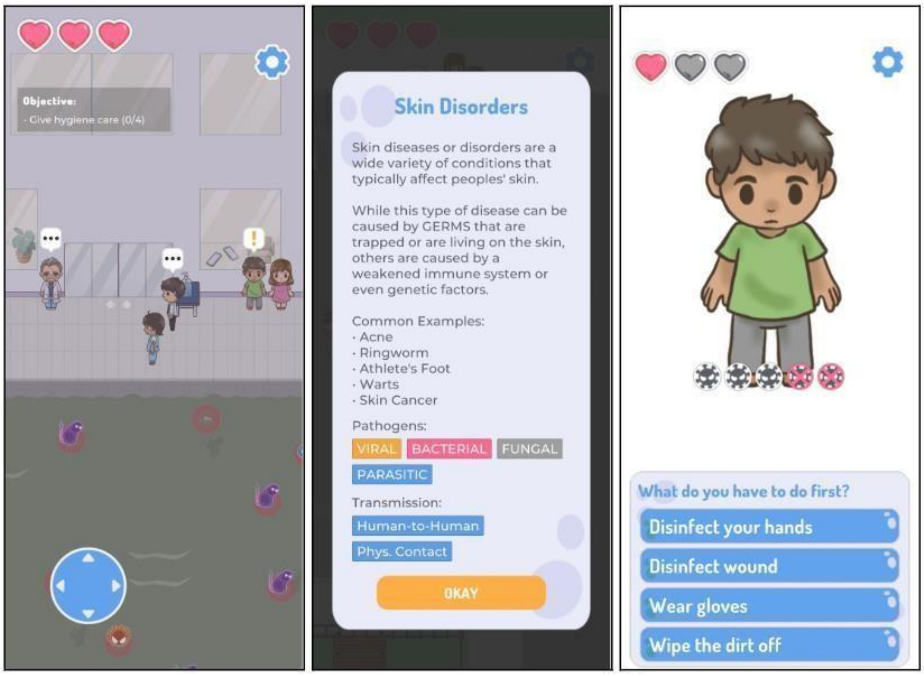

Figure 1. Outbreak Vanguard Game Screens and Battle System

In Outbreak Vanguard, the player enters a world where germs have become visible to the naked eye. The player volunteers to help their local community by joining a crisis management task force called Vanguard. See Figure 1 for in-game screens.

The game follows the Prevention of Diseases and Disorders Domain lessons (Department of Education, 2016) for Grade 4 and Grade 8 students, implemented by having the player choose either the Junior or Senior Hygieneer track. They may try the other track once their main track is finished.

The two storylines are divided into eight levels each. Each level has a plot patterned on their respective Grade Level Learning Competencies as set out in the health curriculum. The Handum team chose to adapt the official curriculum to make it easier for the game to be adapted for use in Philippine schools. For example, in Level 6 of the Senior Hygineer Storyline, the Player helps secure a marketplace where animal-borne diseases are reported to be spreading. This follows the Department of Education Learning Objective H8DD-IIId-e-20 where the student should learn about emerging and reemerging diseases.

Emotional engagement is promoted through day-to-day scenarios for each level. Players can relate to the game environment and quickly grasp how their real lives are affected by invisible germs.

To fulfill the level objectives, the player must navigate the environment to talk to different non-player characters (NPCs) while simultaneously avoiding germs wandering around the level. The lesson is delivered through interaction with the NPCs. Stage and character design were developed to appeal to the target age group of the application to motivate them to play the game.

Assessments involve the game's battle system. In a battle, the player interacts with an NPC or object to reduce the number of germs around while simultaneously maintaining their health, represented by hearts. In each stage, the player chooses one of four choices. Good choices will decrease the number of germs and/or increase the player's health. Wrong choices do the opposite. If the player's health reaches zero, they must redo the entire battle again.

At the end of the stage, the student will be given a short assessment by a Vanguard team member based on the lessons they learned. They must pass this assessment before being able to move on to the next stage.

Graceful failure is present in both the battle system and the end-of-game assessment. If they cannot get the answers correctly, they may quickly redo the encounter again. They may also go after other objectives or talk to other NPCs to review the lesson before trying again.

A teacher using Outbreak Vanguard as part of their lessons can sign up with the Outbreak Vanguard Teacher Portal (https://outbreakvanguard.com). There, the teacher can set up a class. Students can join a class by entering the unique class code ID when they start the game. The teacher can then monitor student performance through the different screens of this website.

Players can have a social engagement with the game when the teacher provides incentives to students who perform well. Collaboration with their classmates in competition with other classes can also promote social engagement. The Teacher Portal also provides study guides to help the teacher discuss the actual lessons of the health curriculum in line with the game.

4. Effectiveness Testing

To test the effectiveness of Outbreak Vanguard in a classroom setting, the team worked with the University of the Philippines Integrated School. A pre-test was given before the students learned their health lessons in the usual way. The experimental group, however, had access to the game. At the end of the lesson, a post-test was given to see if the experimental group learned the lesson better.

Data analysis is still being performed at the time of this paper writing. The results of this testing will be published in a different paper at the 58th Psychological Association of the Philippines Convention to be held in late September 2022.

5. Conclusion

This paper provided a summary of the output of Project Handum. The Outbreak Vanguard mobile game is available for free on the Google Play store starting August 2022. Teachers may sign up on the Teacher Portal website (https://outbreakvanguard.com) or email the Handum team (hello@projecthandum.fyi).

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Relationship Analysis between Listener Face Direction and Utterance in Group Discussion

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Abstract: The authors analyzed the relationship between face direction and utterance during group discussion. For groups of six students, face direction data were collected using video and OpenFace, and utterance data were collected using a microphone array and the Hylable system. The results of the analysis show that the average number of persons who turned their faces differed significantly when the speaker did or did not speak.

Keywords: Group discussion, Utterance, Face direction, Microphone array, OpenFace

1. Introduction

Active learning has gained research interest in recent years (Hartikainen, Rintala, Pylväs, & Nokelainen, 2019). One method of active learning is group discussion which involves frequent conversations. In general conversation, we communicate by combining verbal information, such as spoken language with nonverbal information, typically gestures and gaze (Jones & LeBaron, 2002). For example, in Hybrid meetings, it is difficult for remote participants to be involved in discussions (Yankelovich, Simpson, Kaplan, & Provino, 2007), which may be due to insufficient communication of verbal and nonverbal information. Research on conversation often focuses on verbal information. However, some research also focus on nonverbal information. This area is referred to as multimodal discourse analysis (MDA) (O'Halloran, 2011).

As an example of multimodal information, face direction, such as head pose, is important nonverbal information that indicates the target of speech and the alternation of roles in conversation (Murphy-Chutorian & Trivedi, 2008). As concrete research, Ito et al. (2022) focuses on nonverbal information in group discussions in which neural network models that estimate the persuasiveness of participants using head pose data were constructed. However, Ito et al. (2022) did not analyze the influence of nonverbal information on utterance during group discussion.

Therefore, in the present study, we focus on face direction and amount of utterance in a group discussion and hypothesized that a relationship exists between whether listeners turn their faces toward the speaker and amount of utterance. We used software to detect face direction and a microphone array to detect utterance to verify this hypothesis. We expect that the present study will provide insight for building a better learning environment on not only face-to-face group discussion, but also group discussion in HyFlex classes where communication using nonverbal information is difficult.

2. Method

2.1 Data Collection

We used two types of data: the amount of utterance for each person and face direction during the group discussion. In order to obtain the amount of utterance for each person, the Hylable microphone array was placed in the center of the group. This voice data was converted into amount of utterance. As for face direction, one iPad mini was placed in front of each subject to record the face of each subject. Face directions were computed using OpenFace (Baltrušaitis, Zadeh, Lim, & Morency, 2018) on this video. In order to reduce the risk of COVID-19 exposure, the subjects wore masks with transparent mouthparts.

2.2 Experiment and Analysis

The subjects were 13 Japanese university students who consented to this research. The experiment was conducted on December 2 and 9, 2021. Three sets of 10-minute group discussions were held in order to obtain the data described in Section 2.1. For the experiment, the subjects were reorganized to make three groups with six participants in each (some students participated repeatedly). Before obtaining the data, we held a calibration for face direction. The subjects were instructed to direct their faces to specific angles, and we used the obtained baseline angle for the calibration. This calibration provides accuracy of face direction data.

In order to determine who made an utterance at a particular time, we defined the subject with the maximum amount of utterances in each time frame (5 s) as the speaker, and the other subjects as non-speakers.

3. Results and Discussion

3.1 Utterance Timing and Facing Timing

We visualized the timing when one subject made an utterance (utterance timing) and the timing when the other subjects turned their faces toward the subject (facing timing) (Figure 1). The blue dots indicate the utterance timing, and the red dots indicate the facing timing. Figure 1 shows the results for subject S011 in Group 1. Both A and B in Figure 1 are part of the timing in which Subject S011 spoke. Subject S011 spoke briefly in A and spoke longer in B. The number of subjects who turned their faces to Subject S011 was low in A, while the number of subjects who turned their faces to Subject S011 was high in B. Regarding this result, we assumed that the speaker made longer utterances because the face of the listener turned toward the speaker, and the speaker felt as if he/she was being asked for an opinion.

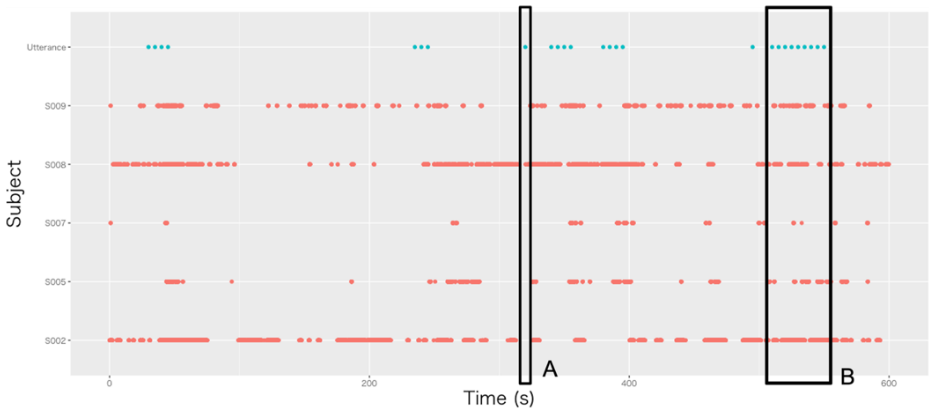

Figure 1. Utterance timing of speaker and facing timing of listener

3.2 Number of People Who Faced the Speaker and Whether the Speaker Made Utterances

Figure 2 shows the number of people who faced the speaker in two conditions: when the speaker was speaking (speaking timing) and when the speaker was not speaking (non-speaking timing). Orange indicates speaking timing and green indicates non-speaking timing. From Figure 2, we can observe the difference in the number of people who faced the speaker between speaking timing and non-speaking timing for all subjects except Subject S005 in Group 1. We interpreted this as it being easier for the speaker to speak when many listeners turned their faces in his/her direction.

Figure 2. Number of people who faced the speaker and whether the speaker made utterances

Next, we conducted an analysis of variance for the boxplot in Figure 2. The results show that, for all groups, the average number of people who faced the speaker was significantly different between speaking timing and non-speaking timing ($p < 0.001$).

Accordingly, since the average number of people who faced the speaker differs significantly between the two conditions, the possibility of a relationship between the number of people who faced the speaker, and the speaking timing/non-speaking timing is clear. Since the two types of data used in the present study were obtained at the same time, it is impossible to clarify the cause and the results from among face direction data and utterance data. However, we believe that, since the faces of the listeners turned toward the speaker, the speaker felt that being expected to speak and the willingness to speak increased. Thus, the number of people who faced the speaker was high during speaking.

4. Conclusion and Future Research

In the present study, we investigated the relationship between whether listeners turn their faces toward the speaker and amount of utterance in group discussions. As a result, having the face of the listener turned toward the speaker increases utterance by the speaker. In addition, a relationship may exist between the number of people who face the speaker and the amount of utterances. A future prospect is to research group discussions in HyFlex classes.

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Chinese EFL Teachers' Reflections of Online English Teaching during the COVID-19 Pandemic: A Qualitative Study

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Abstract: To better understand English as a Foreign Language (EFL) teachers' voices in online English teaching in China, a qualitative case study was carried out by analyzing semi-interviews, and in-depth data of six EFL teachers from a central Chinese university. With thematic analysis, seven themes emerged, including *the choices of teaching platforms or Apps, the negative attitude, the preparation for online teaching, teaching design, teaching assessment, advantages, and challenges*. Overall, the study contributed to the existing knowledge of online language teaching theoretically and practically by providing a Chinese contextual phenomenon of EFL teaching.

Keywords: EFL teachers, online English teaching, technology acceptance, China

1. Introduction

The Chinese government issued the national policy "Suspending Classes without Stopping Learning" to ensure the continuity of teaching and learning during the COVID-19 period. This led most Chinese English as a Foreign Language (EFL) teachers to use the Internet and online platforms as their only teaching medium (Tao & Gao, 2022). The national policy had assumed that teachers had sufficient knowledge in technology, pedagogy, and content (TPACK) to conduct a successful online teaching practice during this particular period (Moorhouse, Li, & Walsh, 2021) since Chinese EFL teachers have been encouraged to integrate information and communication technology (ICT) into EFL teaching to create an authentic language-rich environment for the students whose mother tongue is not English (College English Teaching Guide, 2017). However, the national policy cannot guarantee teachers' technology adoption in their real teaching practice. Moreover, recent evidence has shown that EFL teachers were not positive to integrate technology into their teaching due to concerns about their technological competence and insufficient teacher development training (Gao et al., 2021). Therefore, it matters to know how these EFL teachers perceived ICT-supported online teaching in a pandemic period where online teaching was a must rather than an alternative (Li, 2022). Given that the qualitative research method tends to seek in-depth and detailed information as well as explore how the information relates (Ary et al., 2010), a case study with seme-interviews was conducted in the current study to address the following question:

What are the EFL teachers' reflections about their experience of online English teaching during the COVID-19 pandemic time?

2. Research Methodology

A qualitative approach that can offer deeper insights into the topic was carried out for the study. Such a method was appropriate since factors that influence Chinese EFL teachers' views about online teaching are far more complicated than what general information suggests by quantitative methods (Huang, Teo, & Zhou, 2021). As part of a more extensive investigation, the current study just reported the findings of a qualitative inquiry into Chinese EFL teachers' voices and reflections on online EFL teaching during COVID-19. Six participants were selected from a university in a central Chinese province by a purposeful sampling method. They were chosen mainly for the various demographic information of the interviewees, such as educational background and teaching experience, for maximum variation. To protect participants' information and convenience of data presentation, the participants were referred to as R1-R6. Their basic information is shown in Table 1.1. A face-to-face semi-structured interview on a one-to-one basis was conducted to collect the qualitative data. The ethical issues were informed to the respondents such as their willingness to withdraw whenever they wanted during the whole study session. All interviews were recorded with the participants' permission. The entire duration of interview data collection lasted 30 days because of the participants' tight schedules. The length of each interview ranged from 48 to 135 minutes, with an average of 90 minutes. After the data collection, the data analysis was done thematically. To reduce the potential disadvantages caused by language, interviews in Chinese were followed during interview sessions and only the final reporting was presented in English.

Table 1.1 *Basic Information of Interview Participants*

N	G	YT	ED	AR	CT	CS	OP
R1	M	20	PhD	Lecture	Public English	100+	Ding Talk; Cidaren; We Learn; WeChat
R2	F	14	MA	Lecture	Comprehensive English	40+	Ding Talk; Chaoxing; WeChat; Mooc
R3	M	17	MA	Associate Professor	Reading	100+	Ding Talk; Cidaren; We Learn; Cloud Class; WeChat
R4	F	35	MA	Professor	Western Culture	40+	Ding Talk; Cidaren; We Learn; WeChat; MOOC
R5	F	13	MA	Lecture	Business English	50+	Ding Talk; Chaoxing; WeChat; Mooc
R6	F	6	MA	Lecture	Listening &speaking	40+	Ding Talk; Cidaren; We Learn; Chaoxing

N=Name; G=Gender; YT=Year of Teaching; ED= Educational Degree; AC=Academic Rank; CT=Course of Teaching; CS=Class Size; OP=Online Platforms

3. Research Findings and Discussion

Based on the semi-interview data from six Chinese EFL respondents, the findings were divided into three stages: before, during, and after implementation. For each phase, different themes emerged. The detailed themes descriptions were presented in Table 2.

Table 2. *the Themes Summary from the Interview Data Collected*

Stages	Themes	Sub-themes
Before Implementation	1. The choice of online teaching platforms	a) Stable connection b) Easy operation c) Basic instruction functions
	2. Negative attitude toward online teaching	a) Worries and fears about unknown challenges b) Doubts about the quality of online teaching
	3. Preparation for the online teaching	a) Exploration by themselves b) Seeking external supports c) Conducting a mock teaching
During Implementation	1. Instructional design	a) Student-entered online instructional design b) Unchanged instructional design

	2. Assessment	a) Assessment means b) Assessment results
After Implementation	1. Advantages of Online Teaching	a) Rich resources b) Relaxing environment c) Strengthened management of students' learning process d) Improved teachers' self-efficacy
	2. Disadvantages of Online Teaching	a) Difficulties in conducting online group Activities b) Lack of emotional communication c) Time-consuming for teachers

The findings of the interview data highlighted the critical role of technology in an online context. The themes supported previous research on the technology acceptance model (Davis, 1989; Venkatesh & Davis, 2000), which indicated that the perceived ease of use and perceived usefulness were important factors affecting teachers' technology acceptance. It was suggested to the system developers that one of the basic principles for developing online teaching systems was easy to operate. As for the usefulness, online teaching strengthened the management of the student's learning process and provided rich resources in the study, which was in accordance with the study of Hwang and Wang (2016). Generally, most Chinese EFL teachers in the study experienced a transition from negative attitudes toward online teaching at the beginning to positive and to self-efficacious with cognition and experience increasing. The transition was due to the EFL teachers' commitment and great efforts to online teaching as well as external support such as technological support from peers and teachers' development training (Huang, Teo, & Zhou, 2021). In terms of the disadvantages of online teaching, the issues still existed such as conducting online group activities and lack of emotional interaction.

4. Conclusion

The research theoretically contributed to the existing knowledge of online language education by offering a deeper understanding of Chinese EFL teachers' reflections on their online teaching practice during the COVID-19 pandemic. At the same time, practical implications especially focused on the continuing professional development in TAPCK to improve teachers' motivation and self-efficacy to integrate technology into online teaching.

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Teaching Analytics Across Multiple Systems: A Case Study at a Junior High School in Japan

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Abstract: This study analyzed and visualized the daily behaviors of teachers on multiple systems using Experience API (xAPI). The results revealed that the learning management system was routinely used, while the learning analytics dashboard was not. Further, we examined how the teacher used the dashboard during the experimental classes with a learning analytics researcher. The results showed that the use of e-book readers and dashboards was encouraged on the day when the researcher attended class together. Additionally, the timings when the teacher checked the dashboard were getting earlier in each class. These results imply that the repeated use of a dashboard and the help of an expert foster the literacy of teachers in using educational data in their classes.

Keywords: Teaching Analytics, Data Literacy, xAPI, Multiple Systems

1. Introduction

In Japan, related ministries, and agencies, including Digital Agency and the Ministry of Education, Culture, Sports, Science, and Technology, have released a roadmap for the use of educational data, which describes how teachers can use the collected educational data in the future (Digital Agency, 2022). Additionally, learning analytics dashboards for teachers have been developed for the utilization of educational data. However, providing teacher-facing dashboards does not necessarily encourage teachers to utilize data for their daily classes. we have to first understand how teachers use education data.

Some studies have used log data from the learning management system (LMS) to understand the behavior of teachers (Su, Li, & Chen, 2021). However, the data in the LMS alone do not provide a broad picture of the behavior of teachers. Therefore, Experience API (xAPI) is attracting attention as a technology. xAPI is a technical specification for handling and analyzing multiple data sources (Kevan & Ryan, 2016). It facilitates the documentation of the learning experience. xAPI stores learning experiences in the learning record store (LRS). However, xAPI has mainly been used to visualize the behavior of learners, and few studies have applied it for teachers. This study uses xAPI to analyze and visualize the behavior of teachers from multiple data sources. The purpose of this study is to explore the factors affecting the utilization of data by teachers for their daily classes.

2. Method

2.1 Learning Evidence Analytics Framework (LEAF)

We used data collected from the LEAF system for analyses. The LEAF system is a learning analytics platform that supports teaching and learning by analyzing accumulated educational data (Ogata, Majumdar, Akçapınar, Hasnine, & Flanagan, 2018). It consists of three major sub-systems: BookRoll, Moodle, and LOGPALETTE. BookRoll is an e-book reader, where teachers upload learning materials for students. Moodle is an LMS used to manage courses and resources. LOGPALETTE is the learning analytics dashboard that visualizes the interactions of learners.

2.2 Teacher's Literacy on Educational Data Use

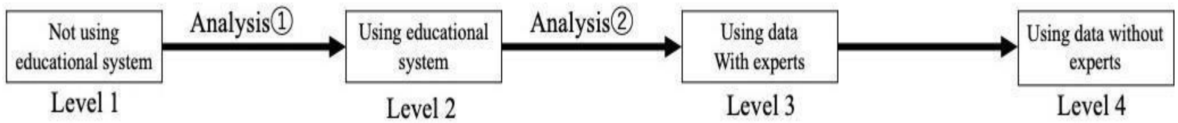

Figure 1. Level of data usage by teachers

As shown in Figure 1, we organized the literacy levels of the teachers on educational-data use. First, we assumed that teachers become familiar with the use of an educational system (Levels 1 to 2), and thereafter, they become familiar with utilizing the data with the help of learning analytics experts (Levels 2 to 3). Finally, they eventually become experts in educational-data use (Levels 3 to 4).

2.3 Data and Analyses

In this study, we extracted logs for the behavior of teachers from the LRS data recorded in the LEAF system. Typically, teachers use the LMS to manage the courses and other information of the learners. Further, LMS works as the starting point for other tools, such as e-book reader and dashboard. The analysis covered 1-month data from June 1 to June 30, 2022. To explore the factors affecting the utilization of data by teachers for their daily classes, we conducted the following two analyses. Analysis 1 analyzed four English teachers: A, B, C, and D, at a junior high school in Japan who had access to the LEAF system. Teacher A was between level 2 and level 3 in Figure 1 because Teacher A implemented an experimental class with an expert. To compare with other levels, we selected other teachers teaching the same subject, whose log data were recorded. Analysis 2 targeted teacher A who had the experimental classes with a learning analytics researcher and conducted a detailed analysis and visualization of some of the classes of the teachers. The experimental classes were conducted in three different classes in the same grade, with the same material, and the same teaching methods.

3. Results and Discussion

3.1 Analysis 1: Comparison of the behavior of each teacher on multiple systems

Table 1 shows the number of xAPI statements for teachers during the analysis period. All four teachers used educational system daily during that period. They all used LMS, two teachers used the e-book reader, and only teacher A used the dashboard. Teacher A, who is related to Analysis 2, routinely used the LMS, while not frequently the e-book reader and dashboard. Additionally, Teacher A used the e-book reader and dashboard on two days other than the experimental day.

Table1. *Log Data for Each educational system*

	Teacher A	Teacher B	Teacher C	Teacher D
LMS	1939	1418	590	916
E-book reader	81	0	0	4
Dashboard	80	0	0	0

3.2 Analysis 2: Visualization of teacher A's use of educational data

Figure 2 visualizes the log data of the function of each tool obtained by Teacher A on June 27 in the three experimental classes. Context select and Active reading were used to check the learning logs and provide feedback in class. Quiz, course, lti, and top view in the LMS were used for course management. On that day, the behavior of the teachers differed despite using the same material and teaching methods among the classes. For example, teacher A checked the dashboard 40 min after the start of the first class, 24 min after the beginning of the second class, and 21 min after the start of the third class to use the data. In other words, the timings when the teacher checked the dashboard were getting earlier in each class. This result implies that the repeated use of a dashboard fosters the literacy of teachers in using educational data in their classes.

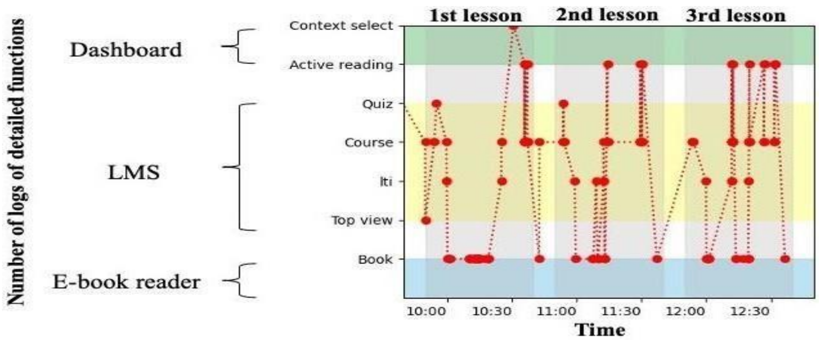

Figure 2. Visualization of teacher A's log data in the experimental classes

4. Conclusion and Future Work

This study aimed to explore the factors affecting the utilization of data by teachers for their daily classes through the analysis and visualization of the behavior of teachers using xAPI. xAPI makes it possible to visualize the behavior of teachers from multiple systems and distinguish the literacy levels of teachers on educational-data use, as shown in Figure 2. The results showed that the use of e-book reader and dashboard was encouraged on the day when the learning analytics researcher attended class with the teachers. Additionally, the timings when the teacher checked the dashboard were getting earlier in each class. These results imply that the repeated use of a dashboard and the help of an expert foster the literacy of teachers in using educational data in their classes. Although further research is required, we think that the results of this study are not limited to the subject of English. A future challenge is to develop a learning analytics dashboard tailored to the data-usage literacy of teachers in a variety of subjects.

Acknowledgments

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Analysis of the Impact Student-Facing Learning Analytics Dashboards on Learning Motivation and Behaviors according to the Motivational Type of Learners

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Abstract: The authors developed two types of dashboards according to learners' motivational type and analyzed the effects of differences in dashboard visualization formats on learning behaviors and motivation. The results showed that some subjects prefer the visualization format of the dashboard regardless of their motivational type. In addition, we confirmed that learners with increased motivation also had increased learning behaviors, such as viewing videos.

Keywords: Learning Analytics, Dashboard, Motivation, Adaptive Learning

1. Introduction

According to a previous study, "learning analytics (LA) has grown from a hypothetical future into a concrete field of inquiry and a global community of researchers and practitioners" (Lang, Siemens, Wise, Gašević, & Merceron, 2022, p. 10) over the last 10 years. Research on LA includes measurement, collection, analysis, and reporting of learning data (Ferguson, 2012). The present study focuses on the reporting function, especially in regard to the Learning Analytics Dashboard (LAD) application. The target users of the LAD include teachers, learners, administrators, and researchers (Schwendimann et al., 2016). This study focuses on learner-facing LAD.

When designing a learning analytics system, it is essential to align with the needs of learners, their individual characteristics, personalization, and adaptivity (Schumacher & Ifenthaler, 2018). Rets, Herodotou, Bayer, Hlosta, and Rienties (2021) developed an LAD in which learners were involved in the design and evaluation and found that each learner had preferences for dashboard contents and wanted a more personalized version.

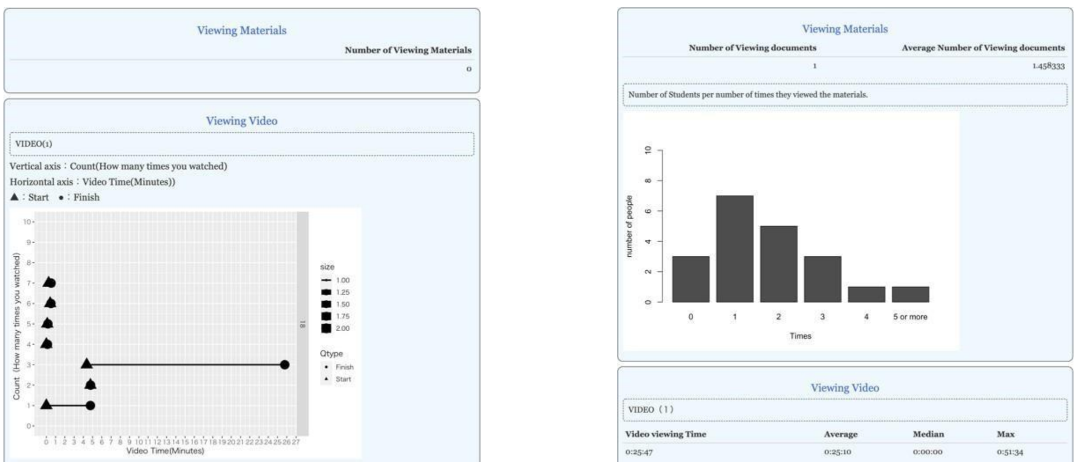
Given this background, the present study aimed to verify the hypothesis that different dashboard visualizations based on learners' motivational types affect their learning motivation and behaviors. In other words, we hypothesized that if the dashboard visualization matched the learners' motivational types, their learning motivation and actions would increase. The findings could be expected to lead to the individual optimization of the LAD based on learning theory and enable more effective feedback.

2. Methods

2.1 Data Collection and Development

To design and verify the effectiveness of dashboards, learning activity data were collected from Moodle, a learning management system (Moodle, 2022). The acquired data included students' viewing logs of the learning videos, materials, and dashboards developed for this study. Learner motivational type was collected using a questionnaire from Sugiyama and Sensaku (2010). Learning motivation before and after viewing the dashboards was also measured using a questionnaire.

Then, we developed dashboards. Ryan and Deci (2000) proposed the self-determination theory and classified motivational types into "amotivation," "extrinsic motivation," and "intrinsic motivation." Based on this, we developed dashboards according to two types of motivation: "(a)intrinsic" and "(b)extrinsic" (Figure 1). The dashboard for intrinsic type visualized one's own learning activity data so that one could understand one's learning situation. On the other hand, the dashboard for extrinsic type visualized other students' learning activity data as well so that they could be compared and evaluated.



(a) Dashboard for the <u>intrinsic</u> type. (b) Dashboard for the <u>extrinsic</u> type. *Figure 1*. Dashboards according to two types of motivation.

2.2 Experiment and Analysis

An experiment was conducted with students in a liberal arts course offered at Sophia University in Japan who provided consent to participate in this research. The experiment was conducted 3 times as shown in Table 1: first with no dashboard, second with a dashboard for intrinsic/extrinsic motivational type, and third with a dashboard of reversed type. To eliminate the influence of the order of the conditions, the students were assigned to two groups in random order.

In order to analyze, we categorized the students into two groups according to their motivational type based on the answers to the motivation questionnaire. Then, we compared differences in their learning motivation and behaviors when they viewed the dashboards fitted and not fitted to their motivational type.

Table 1. *Experiment Framework*

	# 1	# 2	# 3
Group 1	Without dashboards	Dashboard for <u>intrinsic</u> type	Dashboard for <u>extrinsic</u> type
Group 2		Dashboard for <u>extrinsic</u> type	Dashboard for <u>intrinsic</u> type

3. Results and Discussion

First, we showed students' learning motivation. In the questionnaire, we asked the students "Did your behavior and motivation change as a result of viewing the feedback?" According to the results, no students felt that their motivation or behavior had decreased. Also, some learners' learning motivation and behavior did not change with or without the dashboard. Among the students with intrinsic type, 66 percent reported increased motivation and behavior when looking at the dashboard. On the other hand, only 17 percent of students with extrinsic type reported increased motivation and behavior. It was also clear that 33 percent of students had not looked at the dashboard.

Next, we showed students' learning behavior. We calculated the average video viewing rates 3 times ("without dashboards," "with dashboard for intrinsic type," and "with dashboard for extrinsictype") for each of the two types of students. No significant difference in the viewing rates was seen in students with intrinsic type at 3 times ($p>0.05$). Learning behaviors did not change when these students viewed the dashboard for extrinsic type. By contrast, a difference was found in students with extrinsic type ($p=0.03$). Learning behaviors decreased when they viewed the dashboard for extrinsic type.

An analysis of variance conducted on the video viewing rate revealed a significant difference in the viewing rate between the tasks of reports and implementations ($p=0.002$), which suggests that students with the extrinsic motivational type are more likely to be influenced by the learning behaviors of different task types, whereas students with the intrinsic motivational type are more likely to engage in learning behaviors regardless of the task type.

Then, from the viewing logs of the learning materials, we calculated the average number of views viewed as with video viewing rates. Unexpectedly, learning behaviors increased when students with intrinsic type viewed the dashboard for extrinsic type. On the other hand, the number of times students with extrinsic type viewed documents increased during the times using compared with those not the dashboards. Unexpectedly, learning behaviors increased when these students viewed the dashboard for intrinsic type.

In addition, we showed students' evaluations of the dashboard interface design. In the questionnaire, we asked the students about visualizations that they felt would increase and decrease their motivation and learning behaviors. The results revealed that the dashboard for extrinsic type was selected for both questions and the dashboard for intrinsic type was selected only for the visualizations that the students felt would decrease them. Moreover, some students took action immediately after viewing the dashboard to compare the dashboards with their actions, suggesting that real-time visualization may have been more effective for these students.

4. Conclusion and Future Research

In this study, we presented learners with dashboards designed to fit their motivational type and measured differences in the learning motivation and behaviors of learners who viewed each dashboard. The results showed that individual differences existed in learning motivation and behavior changes due to differences in dashboard visualization formats. This suggests the need for individual optimization of dashboard visualization formats.

As a future task, the experiment situation needs to be improved by removing elements such as task differences that are unrelated to the experimental design. In addition, dashboard contents that fit each motivational type more closely need to be designed, and the classification of dashboards to be optimized based on learning theories needs to be examined in more detail.

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Predicting Chinese Secondary School Students' Behavioral Intention to Use an Online Homework System

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Abstract: As a homework delivery format, online homework emerges in accordance with the development of technology to support student learning. Informed studies have demonstrated the impact of online homework on student performance, but the incorporation of online homework into student learning is still challenging, particularly in China. In order to better promote online homework, eight predictors are selected to investigate secondary school students' behavioral intention to use an online homework system based on the extended UTAUT model. Via the proportional stratified random sampling method, a minimum of 339 samples will be selected. Then, a correlational research design will be employed to address the research questions herein. Descriptive and inferential statistical analyses such as Pearson product-moment correlation and multiple linear regression (MLR) will be used for analysis. Lastly, an interpretative qualitative approach via interview will be applied to understand the factors affecting students' behavioral intention to use an online homework system as well.

Keywords: online homework, behavioral intention to use, secondary school students

1. Introduction

Online homework has become an emerging format of homework delivery in accordance with the increasing use of technology in current days, especially during the outbreak of Covid-19. The use of online homework promises many benefits for student learning (Murphy et al., 2019; Wiggins & van der Hoff, 2021). Evidence shows that students, who frequently and regularly use online homework systems, tend to gain better performance (Salame & Hanna, 2020; González et al., 2022).

Similarly, the introduction of online homework has offered Chinese students an opportunity to acquire knowledge effectively. However, research on online homework in the K12 setting in China is relatively limited (Jia et al., 2013). Studies from the aspect of user acceptance, particularly in terms of behavioral intention, are less (Cao & Song, 2020).

Online homework is designated to help students achieve better understanding and mastery of synchronous knowledge. The incorporation of online homework into student learning is challenging, however. The dissatisfied frequency of completion, poor academic performance, decreasing retentions, and procrastinating or gaming behaviors are commonly emerging when students are assigned to do online homework. Extant issues indicate that many Chinese students do not want to use online homework systems.

Given the technological advances, the visible outcome of online homework pushes the demand for the investigation of the usage of the system among Chinese students. Hence, there is a necessity to understand to what extent Chinese secondary school students' behavioral intention to use online homework systems. How will students perceive and respond to their learning when online homework is assigned for them to complete? Moreover, what factors will predict behavioral intention to use online homework among

Chinese secondary school students? It is a question that needs to be investigated urgently as students' behavioral intention to use online homework critically impacts the adoption and acceptance of this learning facilitator, and the outcome of students learning.

2. Research Objective

Current prominence of technology promises the possibility of multiple deliveries of learning in and after class. Online homework subsequently becomes a part of learning consolidation as well. This system enables students to conveniently acquire feedback, access material, then achieve better learning acquisition. Therefore, it is crucial to explore the factors predicting secondary school students' behavioral intention to use online homework systems in China. Because behavioral intention to use is regarded as a vital factor predicting the actual use behavior of technology (Venkatesh et al., 2003; Venkatesh et al., 2012). In this case, this study intends to provide empirical evidence to explore students' intention to use online homework in Chinese secondary school education settings. Accordingly, the following research questions (RQ) will be addressed:

1. What is the extent of Chinese secondary school students' behavioral intention to use an online homework system?
2. What are the relationships between performance expectancy, effect expectancy, social influence, facilitating conditions, hedonic motivation, interest, attitude, technology self-efficacy and behavioral intention to use an online homework system among Chinese secondary school students?
3. What is the proportion of the variance in Chinese secondary school students' behavioral intention to use an online homework system that can be explained by performance expectancy, effect expectancy, social influence, facilitating conditions, hedonic motivation, interest, attitude, and technology self-efficacy?
4. What is the extent of Chinese secondary school students' experience in using an online homework system?

3. Conceptual Framework

The Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003) is identified as one of the most matured theoretical models, providing the essential factors related to the prediction of behavioral intention to use a technology and technology use in the context of an organization (Venkatesh et al., 2012). Four core determinants of intention to use the technology are embraced in the model, including performance expectancy, effort expectancy, social influence, and facilitating conditions. Based on this model, studies on individual acceptance and use of information technology are well documented in an educational context as well (Khechine et al., 2016). The adoption of the original UTAUT model with other new variables has been commonly applied to demonstrate the technology acceptance by students (Lakhal & Khechine, 2017). Subsequently, Khechine et al., (2020) incorporated the four core determinants from the original UTAUT model with intrinsic value construct to identify the determinants of students' intention to use a learning management system.

Besides, in accordance with the advancement of the transformation in the digital technology era, the echo of adoption habits of lifelong learning and acquisition of compelling skills is responded with the assumption of Interest-Driven Creator Theory (IDC) (Chan et al., 2018). Literature also has demonstrated that students who are able to explore their own learning through activities assisted by technology and motivated by their own interests can excel in academics and develop into lifelong learners (Roschelle & Burke, 2019). Therefore, with the acceptance of four core determinants and the adoption of Interest-Driven Creator Theory (IDC) as a lens, the proposed research framework in the current study intends to include interest, hedonic motivation, attitude, and technology self-efficacy as well. Therefore, there are eight predicting factors in the conceptual framework: performance expectancy, effect expectancy, social influence, facilitating conditions, interest, hedonic motivation, attitude, and technology self-efficacy as shown in Figure 1.

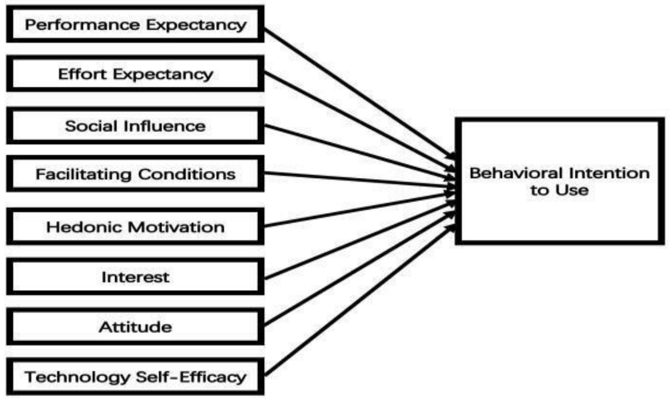

Figure 1. Proposed Conceptual Framework

4. Research Methodology

4.1 Research Design

The study will employ a correlational research design to determine the relationships between the selected predictive variables and the dependent variable. This non-experimental research method is appropriate to ascertain there exists a relationship or to use relationships to predict (Franenkel et al., 2015). Based on the correlational study, the relationship between the independent variables and the dependent variable will be examined. Simultaneously, the degree of the association based on the recorded correlation coefficients will be used to predict an outcome. Subsequently, a semi-structured interview will be conducted to unveil potential predictors of behavioral intention to use an online homework system among students as well.

4.2 Population and Sample Size

The accessible population for this study is 1,466 eighth-grade students at four public schools in the Huicheng District, Huizhou, Guangdong. Based on Cochran's (1977) formula, the sample size is 226. In case there is no response or incomplete answers, oversampling is recommended. Therefore, based on the formula of Bartlett et al., (2001), there are 339 informants out of 1,466 in the sample size in this study. Given that Multiple Linear Regression (MLR) is used in this study, the minimum sample size is required to meet the criteria of MLR. According to Tabachnick and Fidell (2001), the formula for calculating sample size requirements should consider the number of independent variables of the study as $N > 50 + 8m$ ($50 + 8*8 = 114$). Accordingly, a minimum of 339 samples will be included in this study based on the general rule of thumb to select as large a sample as possible from a population (Creswell, 2012).

4.3 Sampling Technique

Proportionate stratified random sampling will be used in this study. Due to the characteristics of the selected schools, the proportionate stratified random sampling technique is appropriate to ensure the representatives of a population. The stratum is the types of schools in this study, including nine-year consistence schools, junior high schools, and middle schools. Subjects are randomly selected from the strata one by one until the desired sample size is achieved. Each number is selected in accordance with a subject in the population so as to represent the population. For the interview, 10 interviewees will be purposively selected.

4.4 Data Collection and Analysis

The data will be collected via an online structured questionnaire, followed by a semi-structured interview. The whole process of data collection is supposed to last eight weeks. Descriptive and inferential statistical analyses will be employed to address the above-mentioned research questions. Via the employment of descriptive statistics, the properties of data collected from the respondents by frequency, percentage, maximum, minimum, mean and standard deviations will be summarized and described to answer RQ 1 in order to outline the status of students' behavioral intention to use the systems. Pearson product-moment correlation and multiple regression will be determined and identified to address RQ 2 and RQ 3. Finally, an interpretative qualitative approach via interview will be employed to answer RQ 4, so as to find out potential or underestimated factors.

5. Proposed Contribution

The findings of this study will contribute to existing conclusions in the acceptance of online homework among Chinese secondary school students, in terms of their behavioral intention to use the system. The highlight of predictors may shift the long-term focus on pure teaching measures and technical support to the intrinsic status of students as well. Additionally, conclusions drawn from the study can be used as a valuable reference for policymakers, company stakeholders and educators.

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Using Digital Storytelling on Scratch to Support Primary School EFL/ESL Students' Writing: A Self-regulated Learning Approach

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Abstract: Self-regulated learning (SRL) is proved to be an effective learning strategy both in a real classroom and in online environments while digital storytelling (DST) is an emerging strategy for teachers to guide their students to learn a language by integrating multimodal artefacts to develop language and communication skills. However, little research has been conducted to investigate their integration, namely, self-regulated digital storytelling (SRDST) for language learning. This proposed study aims to probe the impact of SRDST supported by Scratch, as a new pedagogy and a learning strategy, on learning outcomes and motivation of primary students who learn English as a foreign /second language (EFL/ESL). The study will be guided by the following research questions: 1) How effective is SRDST on Scratch in supporting students in English learning? 2) In what ways and how do primary EFL/ESL students learn English writing through SRDST? 3) What are students' perceptions of the overall SRDST in the English language classroom? 4) What are teachers' perceptions of using SRDST to teach English? In this study, a pre-and post-test quasi-experiment research design will be employed involving about 120 primary grade 4 students. The control group will be instructed based on student textbooks, paper-formed worksheets, and presentation slides. The experimental group will be instructed based on the SRDST approach on Scratch supplemented by paper-formed worksheets and presentation slides. Both quantitative and qualitative data will be collected to yield research findings and answer the research questions.

Keywords: Self-regulated learning, digital storytelling, EFL/ESL, English writing, primary students, computational thinking, Scratch, innovative pedagogy, learner motivation

1. Introduction

Self-regulated learning (SRL) or self-regulation is a conceptual framework to understand learning through cognitive, metacognitive, behavioral, motivational, and emotional/affective aspects (Zimmerman & Schunk, 2011; Sha et al., 2012). SRL can be used as a stand-alone pedagogy or combined with other pedagogical approaches to facilitate student-centred learning (Barrett, 2006). While many researchers investigated the effectiveness of SRL in higher education and adult education both offline and online in the past years (Vanslambrouck et al., 2019; Carter Jr et al., 2020), previous studies proved that SRL can improve young learners' learning outcomes, learning strategies and motivation (Dignath et al., 2008; Hung et al., 2012). Researchers also believed that SRL can foster sustainable lifelong learning skills as it can cultivate learners' generic abilities, such as problem-solving skills, digital competencies, and learning

autonomy (Anthonysamy et al., 2020). Recently, the application of SRL in language learning is emerging, however, limited studies focused on primary
EFL/ESL students' language learning guided by the SRL approach.

In the last four decades, educators and researchers probed the impact of digital storytelling (DST) as a pedagogy in various subject disciplines across primary, secondary, and higher education levels (Wu & Chen, 2020). DST is a technology-supported strategy for teachers to guide their students to learn a language by expressing ideas and meaning through integrating multimodal artefacts to develop language ability and communication skills (Wang & Zhan, 2010). DST has proved to be one of the most popular and effective strategies for improving students' English writing (Burke & Kafai, 2010). However, the research on innovative pedagogies or learning strategies for facilitating primary students' DST is limited. Thus, for addressing the above issues, the integration of SRL and DST, namely self-regulated digital storytelling (SRDST), will have great potential for engaging students in English learning. To fill in the research gaps, this current study attempts to address the following research questions (RQs):

- RQ1: How effective is SRDST on Scratch in supporting students in English learning?
- RQ2: In what ways and how do primary EFL/ESL students learn English writing through SRDST?
- RQ3: What are students' perceptions of the overall SRDST in the English language classroom?
- RQ4: What are teachers' perceptions of using SRDST to teach English?

2. Literature Review

2.1 Self-regulated English Language Learning Supported by ICT

Bai and his colleagues (2021) investigated the effectiveness of using SRL writing strategies to leverage primary students' English writing. They found that with e-Learning tools used, students were significantly improved in terms of employing four types of SRL writing strategies, i.e., planning, text generating, monitoring, and revising. Previous studies have been conducted to assess SRL for language learning through ICT (Şahin Kızıl & Savran, 2018). However, the majority of these studies on self-regulated learning for EFL/ESL learning have been carried out in the higher education sector or secondary education, or outside classroom settings (Yang et al.,2023; Lai & Gu, 2011) but rarely in primary classroom settings.

2.2 Digital Storytelling for English Language Learning

Previous studies revealed that DST had a positive impact on students' English learning performance, students' motivation, creativity, and critical thinking (Liu et al., 2018). However, the age group of these studies was in upper primary levels or secondary levels, and therefore, the effects on young learners in lower primary levels are still unclear. Further, some research found that learning through DST can be learner-centered to increase ESL/EFL students' learning autonomy under teachers' timely feedback and guidance (Kim, 2014). In their systematic review, Wu, and Chen (2020) found that DST yielded positive outcomes in language learning mostly in plot-based story structure, multimedia elements, and story genre. Thus, the current study will probe the effects of DST on students' grammar patterns and vocabulary learning embedded in their English writing process which was insufficiently researched.

2.3 Self-Regulated Digital Storytelling for English Writing

Writing is considered a very challenging skill for ESL/EFL learners (Bai et al., 2021; Leki et al., 2008). When writing in English, different types of SRL strategies can be employed at each of the three stages of writing, i.e. before writing, while writing and after writing (Festas et al., 2015). Previous research also asserted that the integration of computational thinking with English learning had positive impacts on enhancing learners' motivation and academic achievement (Parsazadeh et al., 2021). Researchers believed in the learning potential by integrating formal writing practices and digital creation on Scratch and pointed out the learning possibilities in the intersection of formal writing practices taught during the school day and informal activities of digital creation (Burke & Kafai, 2010; Burke & Kafai, 2012).

3. Research Methodology

3.1 Participants and Samples

The study will deploy a mixed method approach, namely the qualitative and quantitative methods (Creswell & Creswell, 2017). A quasi-experiment research design with pre-and post-tests will be employed involving about 120 student participants, with ages ranging from 9 to 10 years old recruited from selected classes of fourth-grade students from two primary schools with similar academic backgrounds. The recruitment and assignment of participants are expected to help ensure that any differences between and within the experimental and comparison groups are not systematic at the outset of the research.

3.2 Procedure and Instruments

The research will be conducted in formal English learning activities taking place in classroom settings. Both control and experimental groups will be taught the same English topics, using the same set of textbooks, worksheets, and computers. The only difference between the two groups is whether the SRDST approach is introduced by the teachers and used by the students. The duration of the activities will be 10 hours which is the normal duration for Hong Kong primary grade 4 teachers to cover one English unit. Scratch, a widespread visual programming tool used by young learners (Resnick et al., 2009; Kong & Lai, 2021), will be adopted for the experimental group to read and create stories with multimedia elements. The experiment procedure is presented in Figure 1, and the issues to be explored, the instruments to be deployed, and statistical methods to be adopted are presented in Table 1.

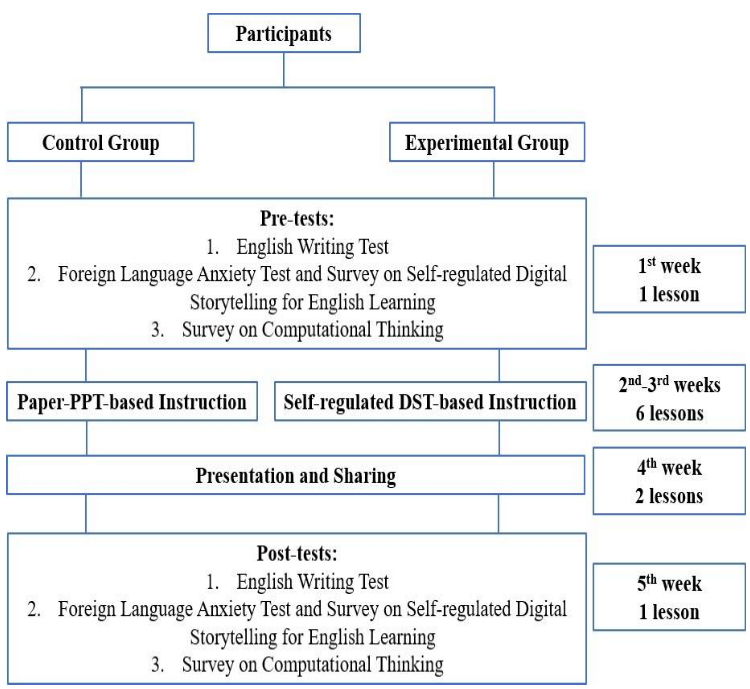

Figure 1. The experiment procedure

Table 1. *Issues to be explored, instrument to be deployed, and statistical methods to be adopted*

RQs	Issues	Instruments/ Data sources	Analysis
RQ1	Correlation among self-regulated digital storytelling	• Pre-/Post-tests of English writing • Foreign language anxiety test • Survey on SRDST • Survey on CT and UAT • Content analysis of students' works	Descriptive statistics, t-test, ANCOVA, Content analysis
RQ2	The effects of self-regulated digital storytelling on EFL/ESL students' English writing	• Pre-test and post-tests of English writing • Foreign language anxiety test • Survey on SRDST • Survey on CT and UAT • Scores of Students' works	Descriptive statistics, t-test, ANCOVA
RQ3	Students' perceptions	• Pre-test and post-tests of English writing • Foreign language anxiety test • Survey on SRDST • Survey on CT and UAT • Focus group interview	Pearson correlation, Thematic analysis
RQ4	Teachers' perceptions	• Focus group interview	Thematic analysis

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The Design and Use of Agent-Based Modeling Computer Simulation for Teaching Technology Entrepreneurship

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Abstract: Entrepreneurship is complex and dynamic. It involves continuously pursuing novel or better products and business models amidst constraints, uncertainty, and constant change among participants (or "agents") in the ecosystem. Entrepreneurship education, therefore, needs to be non-linear. Yet, traditional teaching methods in entrepreneurship came from business management education practices: lectures, case studies, and group discussions–mostly ineffective because entrepreneurship is more dynamic and non-linear. Recent entrepreneurial experiential learning attempts include starting and running a business and using computer simulations to reduce time and cost. This study focuses on the agent-based computer simulation approach. It aims to design and build, using existing open-source frameworks, a simulation environment specifically for technology entrepreneurship, with the choice of technology entrepreneurship forcing novelty and relative market uncertainty in product offerings. The design and selection of technologies will follow evaluation frameworks on the effectiveness of entrepreneurship teaching simulation environments: *fidelity*, *verification*, and *validity*. The expected output will be a simulation environment resulting from multiple design-build implement iterations. The simulation core engine shall interface with a Learning Management System (LMS). The study will also generate insights after simulation sessions with students through educational data mining (EDM) of the resulting logs.

Keywords: computer simulation, entrepreneurship education, agent-based modeling, serious games

1. Introduction and Context

Entrepreneurship is pursuing novel or better products or business models amidst constraints (Eisenmann, 2013). Entrepreneurial education is crucial in fostering economic growth, yet it lacks many aspects in making it more effective (Allegra, 2013). Entrepreneurship education needs to be flexible, but studies show that higher education does not have the flexibility necessary (Matlay and Mitra, 2002, as cited in Tasnim & Yahya, 2013). Entrepreneurship is a complex, chaotic, non-linear, and dynamic process of vision, change, and creation; therefore, it is more than business creation and management (Neck & Greene, 2011; Kuratko, 2005). There are gaps between current theories of the entrepreneurship process involving opportunity recognition, evaluation, and exploitation and how they are taught (Fox, Pittaway, & Uzuegbunam, 2018). The typical teaching methods in entrepreneurship classes are those used in business: lectures, case studies, and group discussions–all ineffective when teaching entrepreneurship (Bennet, 2006, as cited in Tasnim & Yahya, 2013). Educators can still teach entrepreneurship outside these methods (Neck & Greene, 2011; Kuratko, 2005). Previous sources of entrepreneurial understanding were publications, direct observation, and speeches or presentations by practicing entrepreneurs. Entrepreneurship education has expanded with business plans, consultation with practicing entrepreneurs, and computer simulations (Kurtko, 2005). This study focuses on the computer simulation approach.

A *simulation* is a self-contained immersive environment in which the learner interacts within the environment in an attempt to learn or practice skills or knowledge (Kapp, 2012). Simulations allow cost-effective training that would otherwise be costly and time intensive to set up in a real scenario (Kapp, 2014, as cited in Almeida & Simões, 2018). People in education define a *game* as any contest (play) among adversaries (players), operating under constraints (rules) for an objective: winning or pay-off (Tasnim & Yahya, 2013). *Serious games* are computer-based learning simulations that engage players in realistic activities designed to increase knowledge, improve skills, and enable positive learning outcomes (Prensky, 2001; as cited in Fox et al., 2018). Simulations and serious games have storylines and can be competitive and keep score (Almeida & Simões, 2018). Serious games, unlike entertainment games, focus on problem-solving tasks and incorporate the imperfect nature of interactions with the natural world (Susi, Johannesson, & Backlund, 2007; as cited in Fox et al., 2018). This study aims to design and observe the usage of a computer simulation environment specifically intended for technology entrepreneurship students, with the choice of technology entrepreneurship implying novelty and relative market uncertainty in product or service offerings.

An *agent* is an autonomous individual that can behave and decide independently. Agent-based Modeling and Simulation (ABMS) covers interactions among independent agents (Macal & North, 2005).

2. Research Questions

The following questions properly establish the significance of the study, all in the context of technology entrepreneurship learning: RQ1) What aspects of technology entrepreneurship education are fit for simulation? RQ2) What elements of computer simulations or serious games are critical for learning entrepreneurship? RQ3) What features must be present when designing and implementing a serious game platform for entrepreneurship education? RQ4) How would the efficacy of serious games be measured based on learning outcomes? For RQ1 and RQ2, consistency with the natural world is essential, so the study will consider a framework or a set of criteria for evaluating computer simulations and serious games. For RQ3, the study will include a technology scan of various computer simulation tools and techniques. For RQ4, the review will cover several assessment techniques and design criteria involving simulation for entrepreneurship education (not necessarily already covered by computer simulation and serious games).

3. Related Work

Neck & Greene (2011) present three traditional different "worlds" used to teach entrepreneurship: *entrepreneurial* (teaching and observing the entrepreneurial personalities, attitudes, discussing exemplars), *process* (business plan writing, case method), and *cognition* (mindsets, ways of thinking entrepreneurially, and knowledge structures to assess, decide, and make judgments on opportunities, creation, and growth). They also offer a fourth approach involving entrepreneurship as a *method* in contrast to a *process*, which implies predictability. Some methods are starting a business, design-based learning (observation, fieldwork, and understanding value-creation), and reflective practice. Another method uses *serious games*, simulations, multimedia instruction, and interactive activities to compact the business creation process. Serious games are innovative tools for developing entrepreneurial skills such as strategic management, leadership, communication, negotiation, or decision making (Almeda & Buzady, 2019; Tasnim & Yahya, 2013).

An *agent* is an autonomous, self-contained, and self-directed individual with characteristics and rules governing behaviors and decision-making capability. In complex social processes (including entrepreneurship), agents represent people or groups of people, and agent relationships represent processes of social interaction (Gilbert and Troitzsch, 1999, as cited in Macal & North, 2005). Agent based Modeling and Simulation (ABMS) covers interactions among independent agents (Macal & North, 2005). Examples of recent work involving ABMS with critical complex environments during COVID-19 involve supply chain recovery (Rahman, Taghikhah, Paul, Shukla, & Agarwal, 2021) and economic activities (Kano, Yasui, Mikami, Asally, & Ishiguro, 2021).

Low et al. (1994) and Hindle (2002) are early attempts at using computer simulation in entrepreneurship education (Fox et al., 2018). Hindle (2002) finds that experiential learning and the generation of empathy for the “real-life” situation are vital components of entrepreneurship education. Hindle (2002) also raises the issue involving the timeframe of a business venture exceeding an academic subject's term duration. This difficulty is why a simulation game could address this issue. Allegra et al. (2013) used PNPVillage for students to manage a simulated tourist resort. Other tools mentioned in the literature include SKY HIGH (Hindle, 2002), Virtual Business Retailing (VBR) software (Yen & Lin, 2020), SimVenture (Bellotti et al., 2014; Fox et al., 2018), FLIGBY (Almeida & Buzady, 2019), and GoVenture (Fox et al., 2018). ABMS software packages like NetLogo (Wilensky, 1999) and Python-based MESA (Kazil, Masad, & Crooks, 2020) are free, open-source, come with example models, are customizable, and extensible.

Centralized decision engines, where rules and functionalities reside, become problematic as rules become more complex. The resulting delays in feedback make it difficult for users to see the repercussions of their decisions. Artificial intelligence, new programming paradigms, and the ability to decentralize the running of agents may help alleviate these problems (Allegra et al., 2010).

Feinstein & Cannon (2002) propose an evaluation framework for entrepreneurship serious games with three criteria: *fidelity* (realism of the simulation), *verification* (the model operates as intended), and *validity* (the model and the natural world reach the same conclusions). Hindle (2002) proposes success criteria: *adequate suspension of belief, unambiguous communication, technical reliability, and cost benefit assessment*. These attributes and success criteria are the combined theoretical framework for the simulation environment design in this study.

It has been challenging to look for literature on integrating a computer simulator and a Learning Management System (LMS), especially related to entrepreneurial learning, with Allegra et al. (2013) being one of the exceptions. Most serious games for entrepreneurial education also do not include an integrated assessment process of the developed entrepreneurial competencies (Almeida and Buzaidy, 2019), implying a lack of LMS integration as observed in other areas (Queirós, Leal, & Paiva, 2016). In addition, most of the simulation software packages mentioned in the studies are off-the-shelf with minimal room for customization. This study aims to fill the gaps in work on the following: 1) customizing ABMS software to support additional entrepreneurial concepts, 2) extending the opensource ABMS software to allow competition, 3) integrating these ABMS platforms with LMS, and 3) providing educational data mining capabilities for the simulation environment.

4. Research and Implementation Method

The study will take at least two cycles, with additional ones to allow enhancements as new findings and insights emerge. The design, based on past work, must align features with the learning outcomes of the B.S. Information Technology Entrepreneurship (BS ITE) Program of the Ateneo de Manila University in the Philippines. The early prototypes will involve entrepreneurial concepts that are “architecturally significant.” A candidate concept is Rogers’ (1995) theory of diffusions of innovation (Meade & Islam, 2006). Early prototypes will use NetLogo and then migrate to MESA. The simulation engine will connect to an LMS. Students will then use the prototype to compete against each other for top scores in various business metrics. Each session will have at least three rounds with a debrief and assessment of participants by facilitators in between. Students will reflect on the experience and submit their insights through the LMS. At the end of the session, simulator logs and student insights captured in the LMS will go through analysis using exploratory educational data mining (EDM) techniques, which will feed into the subsequent iterations of the simulator build.

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Interplay of Cognitive, Affective and Ecological Factors Influencing Teachers' Technology Integration Beliefs: A Contextualized Model

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Abstract: Teachers' beliefs change have been studied by many researchers and there are multiple models of belief change. Even though most of them agreed that cognitive, affective and contextual factors play a crucial role in forming beliefs, less attention is given to the contextual factors and the complex nature of interactions that happens within the ecology of teachers. Similarly, none of them developed by taking into account the Indian context. So, to fully capture the complex cognitive-affective-ecological factors that influence teacher beliefs about technology integration, we are trying to come up with a new model by identifying important factors relevant to the Indian context and augmenting them with the existing models. In order to identify India-specific factors, we designed a qualitative multi-case study. The study is ongoing, so far we have completed data collection with 14 secondary and high school science teachers from the Thrissur district of Kerala, India. Data is analysed using a thematic analysis method to extract themes.

Keywords: Teachers' beliefs, Technology integration, Belief change, Learning ecosystem

1. Introduction

The broad Goal of this thesis is to understand how factors connected to individual characteristics and context contribute to teachers' beliefs about technology integration and its change. My motivation to choose this area is mainly because of two reasons. First of all, being a teacher educator involved in providing various professional development programmes to school teachers, I have noticed a lot of differences in the ways teachers experienced the same learning content and the variations in the implementation of this knowledge in their actual teaching practice. Secondly, literature shows that teachers' decisions to adopt and frequently use technology in the classroom are mediated by their attitudes and beliefs toward technology (Russell et al., 2003). So, identifying teachers' beliefs, understanding the process of belief change and the role played by the individual characteristics and contextual factors have implications for teacher educators and researchers working on effective integration of technology-focused solutions in the classroom and designing teacher professional development programs.

While most researchers agree that beliefs form and change through a dynamic interplay of cognitive, affective and ecological factors, existing models of belief change are predominantly focused more on the individual characteristics of the teachers and inadequate to account for the complex interactions happening between teachers and the ecosystem of the school. This creates a crucial gap in our understanding of the belief change process. Similarly, none of the existing models of belief change is constructed by taking into account the peculiarities of the Indian context. In our work, we will try to address this research gap by capturing essential factors influencing teachers' beliefs about technology integration from the literature and augmenting them with Indian context-specific factors identified through our studies. This will help us to come up with a new model of teachers' beliefs about technology integration. Following are the research questions of this thesis (1) What are the factors that influence teachers' beliefs about technology integration? (2) How do cognitive, affective and ecological factors contribute to the change in teachers' beliefs and practices about technology integration?

2. Theoretical Framework

2.1 Teachers' Beliefs about Technology Integration

Teachers' beliefs in general and teachers' beliefs about technology integration in specific have been studied extensively by researchers (Park & Ertmer, 2007). According to Russell et al. (2003), teachers' decisions to adopt and frequently use technology in the classroom are mediated by their attitudes and beliefs toward technology. Miller et al. (2003) consolidated various studies and found that teachers' beliefs about technology are comprised of three components: pedagogical beliefs about teaching and learning, self-efficacy beliefs for using technology, and beliefs about the value of the use of technology. The studies conducted by Taimalu & Luik (2019) reiterated that these three components were found to be the main predictors of teachers' use of technology for pedagogical purposes.

2.2 Models of Teachers' Belief Change

To analyse the process of change in teachers' beliefs about technology integration and to understand the role of cognitive, affective and contextual factors in this process, we use the model of conceptual change. Even though the models of conceptual change were primarily developed to analyse knowledge acquisition, they could also be applied to analyse changes in beliefs (Gill et al., 2004; Posner et al., 1982). From the literature review, we have identified the integrated model of Language Teacher Conceptual Change (LTCC) by Kubanyiova (2012) as a potentially appropriate model for our analysis.
The LTCC model is an updated version of the Cognitive-Affective Model of Conceptual Change (CAMCC), which integrates cognitive frameworks of belief change with motivational and affective factors (Gill, 2003).

2.3 Learning Ecosystem

The idea of the ecology of human development was popularized by Bronfenbrenner (1979). According to him, an ecological approach is useful to explore the interrelations between the individual and the changing contexts in which development is embedded (Bronfenbrenner, 1979). Barron (2006) defined a learning ecology as "the set of contexts found in physical or virtual spaces that provide learning opportunities. Each context is made up of unique activities, resources, relationships and the interactions that result from them". Hecht & Crowley (2020) used the term learning ecosystem to emphasize the systems and presented an argument to decentre the focus on individuals to enable new ways of thinking about the learning ecosystem. The researchers Zhao & Frank (2003) in their study of technology use in 19 schools found that an ecological perspective can provide a powerful analytical framework for understanding technology uses in schools. To use the learning ecosystem as a lens to view our study, we adopt the metaphorical equivalents established by Zhao & Frank (2003): (a) schools are ecosystems, (b) technology use are living species, (c) teachers are members of a keystone species, (d) reform inputs are invasions of exotic species.

3. Research Methodology

The central endeavour in the present thesis is to understand the beliefs and subjective world of the teachers' experience in integrating technology into their teaching-learning process. Teachers construct meanings as they engage with the world, based on their historical and social perspectives. We consider teachers' actions as potential resources to understand the hidden meanings and intentions. Hence the thesis follows a constructivist worldview. Similarly, we use a multi-case study research design to develop an in-depth analysis of each teacher. Collecting data involves semi-structured interviews with individual teachers, classroom observation, eliciting teacher reflections, survey questionnaires and observing teachers' continuing professional development (CPD) programmes. The philosophical worldview, the research design that is related to this worldview, and the specific methods of research informed us that our thesis tends to be a more qualitative approach (Creswell, 2014).

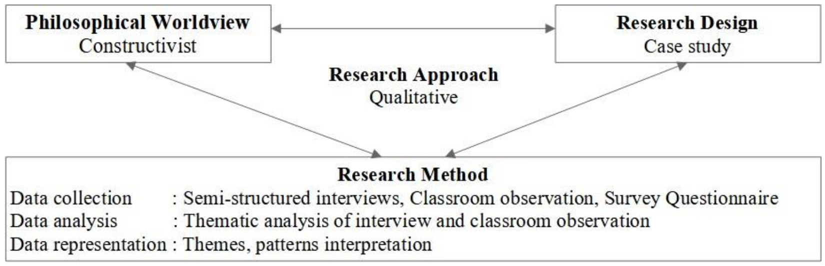

Figure 1. Overview of Research Methodology

3.1 Exploratory Study

A multi-case study was conducted among two secondary school teachers in the state of Kerala, India. This study was conducted during the covid pandemic and began in mid-2020, a few months after the lockdown in India. The study found that the teacher who had undergone training in the use of technology did not change his beliefs as much as the teacher who had low training in technology use. The support from colleagues, concern for students' future and a sense of community played a significant role in this observation. Overall, the study helped to focus on context and its role in the development of teachers' beliefs about technology integration and unpacking contextual factors. The results are published at the 16th International Conference of the Learning Sciences 2022 (Nandan & Murthy, 2022).

3.2 Primary Study

The objective of this study is to identify factors influencing teachers' beliefs about technology integration which are highly important in the Indian context and augment these factors with the essential factors extracted from the literature. The outcome of this study would be a model for explaining how teachers' beliefs about technology integration change and the role of cognitive, affective and ecological factors. The study uses a multiple-case design and follows a theoretical replication logic (Yin, 2018).

3.2.1 Participants

The study has been designed for secondary and high school science teachers from different types of schools (government and government-aided-private) in the Thrissur district of Kerala. Teachers who are going to participate in the continuous professional development (CPD) programme on integration of technology, conducted by Kerala Infrastructure and Technology for Education (KITE), are selected. We used a 'maximum heterogeneity sampling' strategy (Patton, 2015), to maximize sample variation.

3.2.2 Data Collection Procedure

Stage 1 - Before teachers attend the CPD programme: The study description and consent forms will be provided to teachers, and an overview of the study goals will be explained. Semi-structured interviews will be conducted with the teachers to elicit the overall experience of using technology and the factors affecting this process. Similarly, Teachers' Beliefs Regarding Technology Use Survey-TBTUS (Park & Ertmer, 2007) will be used to identify the current status of teachers' beliefs about technology integration.

Stage 2 - After teachers attend the CPD programme: The researcher will visit teachers at three-month intervals and stay with them for 3-5 continuous days. The researcher will probe teachers by asking them to use a particular technology for a particular topic (teacher should feel that the researcher recommends it very naturally when sitting in the lesson planning phase). The teachers are expected to express their ideas about using or not using suggested technology in their classroom and the rationale behind their choice. This may act as a lens for understanding teachers' underlying beliefs about technology integration. Teachers' actual classroom practice will be observed using an observation schedule. Field notes will be prepared to collect details about contextual factors and the affective states of teachers.

3.2.3 Analysis of Data

The recorded interviews will be transcribed into Malayalam text and then translated into English for further analysis. We will use the learning ecosystem as a lens and the model of belief change as an initial 'coding frame' for structuring transcribed data (Schreier, 2012). We will do a thematic analysis of the interview and observation data and present the analysis in the form of themes and their interconnections. The results of the survey questionnaire will be analysed and the results will be augmented with the results of interviews and observations.

4. Ongoing and Future Work

The study is ongoing and so far we have completed stage 1 of data collection with 14 school teachers. Data is transcribed into Malayalam and translated into English. Analysis of the data is progressing. Stage 2 of data collection will be carried out simultaneously with the data analysis. Once the thematic analysis of complete data is over and come up with themes which are specific to the Indian context, we will try to augment the themes with the existing models and come up with a modified model. We will also do the expert validation of the model.

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Developing Student Agency Through Feedback Seeking Practices in a CSCL environment

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Abstract: Despite significant theoretical advancement on student agency in feedback, most attention has been focused on students' actions toward the feedback received from teachers and peers. Current literature presents gaps in getting learners to seek feedback and understanding feedback seeking tendencies in K-12 learners. With the rapid technological advances and societal changes in the twenty-first century, it is increasingly vital for students to develop feedback seeking practices to constantly self-improve and keep up with the changing times. My research investigates the development of feedback seeking practices in primary school students within a CSCL environment. Design-based research would be conducted where a set of design principles derived from literature would be tested to derive insights into designs to facilitate student agency in feedback practices.

Keywords: Student agency, feedback seeking, design-based research, CSCL

1. Background

Feedback has been widely acknowledged as a vital component of effective learning (Hattie & Timperley, 2007); however, the role of feedback has yet to realize its true potential (Henderson et al., 2019). Though extensive studies examined how to increase students' receptiveness to non-solicited feedback (e.g. improving the timing and content of feedback), the field of feedback still faces the challenge of cultivating student agency in feedback practices, specifically in student-solicited feedback. Solicited feedback gathered from student-initiated feedback seeking practices remains relatively under-researched (Molloy et al., 2020). While more attention has been dedicated to recasting feedback from a teacher-led process to a learner-centred endeavour (Carless & Boud, 2018), existing efforts stopped short of envisioning learners as active seekers capable of initiating the feedback process (Joughin et al., 2021). This highlighted the challenge in designing learning environments to cultivate student agency in feedback seeking practices. With evidence from computer-supported learning (CSCL) literature supporting social and cognitive processes (Hertz-Lazarowitz & Bar-Natan, 2002), this study leverages the affordance of CSCL to create designs to cultivate agency in feedback practices.

2. Research goals

This study aims to investigate designs to cultivate student agency through FBS practices in primary school CSCL English classes. The objectives for this study come in four folds: (1) shed light on existing FBS practices in a primary school English class; (2) derive and test a set of design principles for cultivating FBS practices; (3) gather insights on how the design is enacted and (4) examine the effects of the enacted design. My research contributes to the investigation of designs to cultivate student agency amongst primary school learners, aiming to nurture student-initiated feedback practices. Findings from this study could contribute to understanding how FBS can be cultivated in a primary school classroom. Specifically, my research addresses the following research questions:

1. What are the existing feedback seeking practices in an upper primary English class?
2. What design principles enable the cultivation of feedback-seeking practices in learners?
3. How is the design implemented by the primary school English teachers?
4. What are the effects of the designed learning environment?

3. Literature review

Feedback seeking (FBS) behaviour originated in the field of organisational psychology and is defined as ‘‘a conscious devotion of effort towards determining the correctness and adequacy of behaviours for attaining valued end states’’ (Ashford & Cummings, 1983). FBS has extensive literature in business organisation studies and is recognised as a complex process involving the characteristics of the feedback seeker, perceived characteristics of the feedback provider, environmental factors and the feedback outcomes (Anseel et al., 2015). Over the last five years, an increase in interest in FBS within the education context has been observed. Through FBS, students are recast from passive receivers of non-solicited feedback to active seekers of feedback (Joughin et al., 2021). This revamps the paradigm of feedback from a formal teacher-led process to an informal practice that students can leverage to improve their learning (Joughin et al., 2021). While a wealth of empirical evidence has emerged in the fields of feedback seeking in organisational psychology, it is uncertain whether these findings might translate to the education setting.

Existing studies on FBS practices in education present a gap in implementation designs to cultivate FBS. Similar to the FBS studies in organisational psychology, most studies focused on uncovering the antecedents of feedback seeking. Examples of antecedents investigated in current literature include goal orientation (Leenknecht, Hompus & van der Schaaf, 2019), receptivity to critical feedback (Oktaria & Soemantri, 2018) and perceptions of feedback source (Pinasthika & Findyartini, 2022). In addition, existing studies generally occur in tertiary education, mainly in medicine (e.g., de Jong et al., 2017; Milan et al., 2011) and business management (e.g. Hwang & Francesco, 2010). The limited application to the K-12 context results in limited evidence-based pedagogical knowledge on cultivating FBS practices for younger learners.

Five design principles were distilled based on the implementation-based research conducted on FBS in education to serve as guidelines to inform implementation designs (Bell et al., 2013). The design principles are learning culture, agency, conception, discernment and reflexivity.

Table 1. *Initial set of design principles for FBS.*

Design principles	Description
Learning culture	Provide a safe and non-judgmental learning environment. Create a learning culture that embraces feedback solicitation.
Agency	Provide opportunities for student-initiated feedback seeking. Provide prompts to guide students in self-assessing and improving.
Conception	Broaden students’ understanding of feedback beyond formal learning and non-solicited feedback.
Reflexivity	Encourage student reflections and allow revisions to students’ work.
Discernment	Encourage solicitation of critical feedback.

Learning culture. Literature suggests that a safe and non-judgemental learning culture that embraces FBS is vital to helping students develop FBS practices. Multiple studies have shown that learning cultures influence the likelihood for learners to engage in FBS. For instance, the teachers developed a supportive learning culture by collectively discussing the role of feedback to normalise FBS practices. Through the discourse, the students formed a more mutually supportive learning community that embraces the purpose of FBS in learning.

Agency. Existing FBS designs facilitate FBS by providing opportunities for student initiated FBS and prompts to develop student agency in self-assessment processes. For instance, students were given more avenues to seek feedback through self-assessment exercises (e.g., gathering feedback forms (de Jong et al., 2017)) and asynchronous discussion forums (Hwang & Arbaugh, 2006; Hwang &

Francesco, 2010). Fletcher's (2018) study guided students to be more agentic using planning templates with scaffolds to guide students towards developing student autonomy and FBS practices.

Conception. The design principle of conception suggests that it is vital to broaden students' understanding of feedback. Examples include introducing feedback not just in formal learning but informal learning (Gaunt et al., 2018), familiarising students with both solicited and non-solicited feedback (Milan et al., 2011) and different sources of feedback (e.g., peers, resources, family).

Reflexivity. Literature suggests that reflections and revisions are essential to develop FBS practices. Reflection allows students to examine their progress and recalibrate their prior conceptions, prompting learners to seek feedback to improve in their learning endeavours (Diefes-Dux & Cruz Castro, 2022). Opportunities for students to revise their work also promote FBS practices as learners seek feedback to make improvements in their revision attempts (Cutumisu et al., 2019)

Discernment. The discernment design principle suggests that students should solicit critical feedback. In Cutumisu et al.'s (2019) study, students that chose the option to seek critical feedback had more positive learning outcomes relative to students who sought positive feedback.

4. Methodology

This study adopts a design-based research (DBR) methodology (Easterday et al., 2018) that will last three cycles. The study begins with teacher interviews, student focus group discussions and a 4-week baseline study to examine the existing FBS practices in the primary school English class. Insights gathered from the interviews and baseline study will help conceive and improve the implementation designs for the upcoming cycles. The subsequent cycles for the DBR will last for five weeks each. The first cycle aims to assess if the conjectures of the existing literature are valid within the primary school context. Results from Cycle 1 will help inform the design of cycle 2. Cycle 2 will add conjectures related to the Discernment design principle, which have yet to be validated in existing literature (denoted by dotted arrows in Figure 1). Lastly, the results from cycle 2 will inform the design of cycle 3.

Two primary 5 English classes (80 students) from a Singapore government school would participate in this study. The two classes' English teachers will co-design the implementation design with the researcher. Primary 5 students (age 10 – 11) are selected as the students are beginning to learn composition writing, which allows greater opportunities for student agency since students will be working more independently to produce their stories. Students from both classes will engage in English composition writing lessons where they conceptualise their composition ideas and use *Knowledge Forum* as a supportive technology to collaborate and improve each other's composition ideas. Students will also reflect on their progress, seek feedback and make revisions to their composition drafts.

Figure 1 shows the initial conjecture map conceptualised through the design principles gathered from the literature review of FBS practices in education. The refined conjecture map frames the analysis for this DBR (Chen & Wu, 2019; Sandoval, 2014). Data analysis will emphasize the mediating processes and the outcomes of the implementation as denoted in Figure 1.

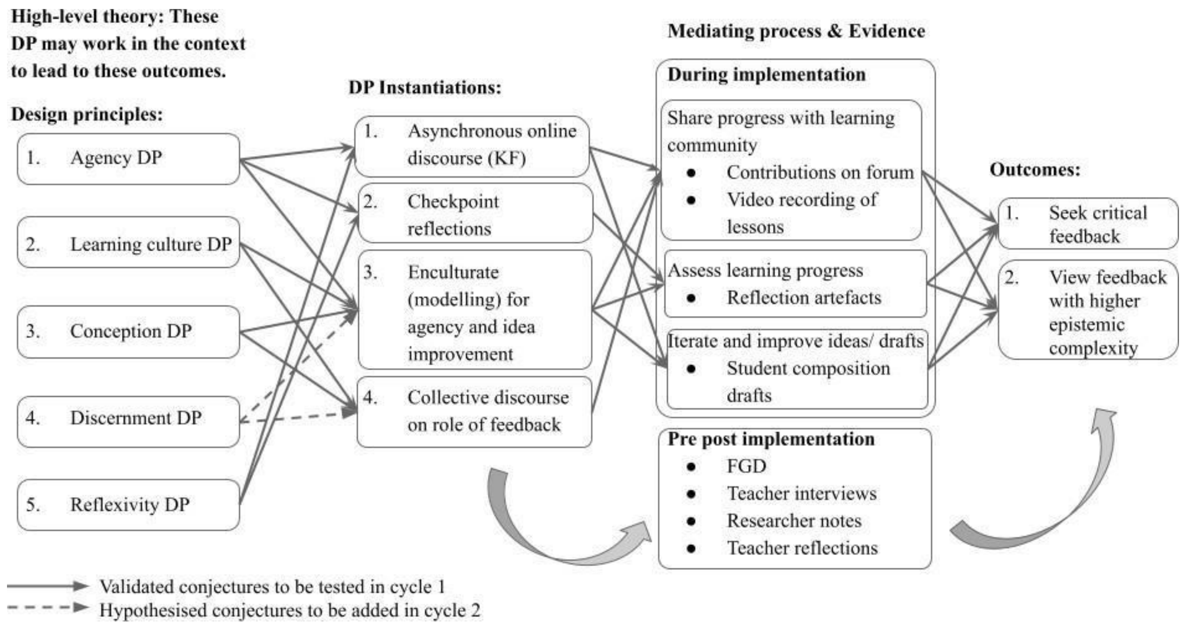

Figure 1. Initial conjecture map for the implementation.

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RE: Letter of Support for Ms LEE Min

Ms Lee Min joined the NIE PhD programme in Aug 2021. Since then, she has completed the coursework component of the programme and is currently planning to defend her proposal for the qualifying examination of the programme. This paper captures some key ideas and conceptualization of her intended study. She aims to complete her PhD study by Aug 2025.

Ms Lee is keen to pursue her study on developing students' agency through feedback-seeking practices in a computer-supported collaborative learning (CSCL) environment. This focus of research fits the interest of the ICCE community. Following Sandoval (2014) clarification of design-based research, she has started using a conjecture map to frame the analysis of the learning environment for design-based research.

I fully support Ms Lee's participation in ICCE and I believe she can benefit from the experts' feedback from this community.

Yours faithfully

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An Institute of NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

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Learning Log-Based Group Work Support: GLOBE Framework and System Implementations

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Abstract: Group work activities can promote the interpersonal skills of learners. To support the teachers in facilitating such activities, we suggested a learning analytics-enhanced technology framework, Group Learning Orchestration Based on Evidence (GLOBE) with data-driven approaches. We designed and implemented a group formation system using genetic algorithms to form groups using learning log data. Even if there is no existing data, we presented a paradigm of continuous data-driven support for the whole group learning process, incorporating the peer and teacher evaluation results as input to subsequent groupings. Further, utilizing accumulated group learning evidence in such an ecosystem, we aim to explore predictive group formation indicators which can lead to automatic group formation based on teachers' purpose in different contexts for desirable performance in subsequent group learning phases.

Keywords: CSCL, learning analytics, group formation, group work implementation, data-driven systems, predictive modeling

1. Research background and goals

Collaborative learning is progressively adapted in various pedagogical contexts where participants work together to share ideas, help each other or accomplish team goals (Dillenbourg, 1999), which benefits their soft skills development. Nowadays, computer-supported collaborative learning (CSCL) (Stahl et al., 2006) and learning analytics (LA) (Siemens, 2012) provides digital tools and data support, bringing immense opportunities to scaffold group work activities.

However, obstacles to providing valid CSCL support still exist. In terms of group formation, teachers tend to resort to random grouping or just pairing neighboring students owing to difficulties to do it in a real-time manner (Salihoun et al., 2017). Students from traditional classrooms seldom use digital tools, which leads to a cold start problem for the lack of enough learning logs to create learner models for group allocation (van der Velde et al., 2021). Even with CSCL support, teachers can get overwhelmed if they do not know how to use CSCL tools for orchestration. Currently, researchers focus on LA tools during the orchestration phase of the group work, while valid support for other phases in a data re-usage perspective deserves further attention as well.

In this research, we put forward the Group Learning Orchestration Based on Evidence (GLOBE) framework to support group work with data-driven systems. This thesis will talk about the data-driven system design and empirical implementations surrounding the phases of GLOBE with iterative data flow. We shall conduct several empirical studies to investigate the impact of LA-enhanced systems in different learning contexts, and in turn figure out predictors of successful group work from these inputs to orchestrate an ecosystem. The main research questions goes as follows.

Q1: How to design a group formation tool using multiple attributes of student model data?
Q2: How to support the whole group learning process with continuous group work data?
Q3: How to orchestrate an ecosystem for automatic group formation with predictive indicators?

2. Research framework

2.1 Group Learning Orchestration Based on Evidence (GLOBE)

Group Learning Orchestration Based on Evidence (GLOBE) provides a framework for group learning support with data-driven approaches in the learning analytics-enhanced environment (Liang et al., 2021a). As illustrated in Figure 1, the data-driven workflow covers four phases: group formation, orchestration of group work, evaluation of group work, and reflection after group work. Currently, the algorithmic group formation system and the peer evaluation system instantiate the GLOBE framework as two organic components of a Learning Analytics Dashboard (Majumdar et al. 2019).

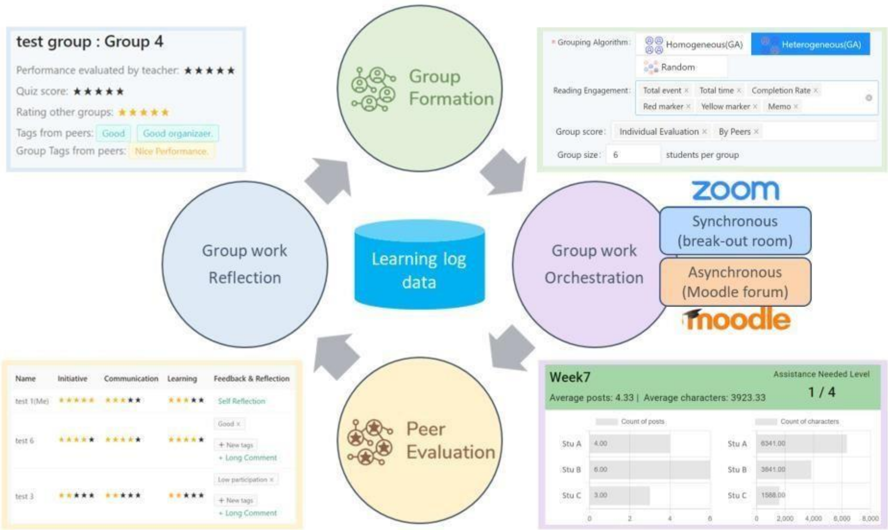

Figure 1. Systems used in different steps in the GLOBE framework (Liang et al., 2021a).

As for the group formation module, underpinned by the first version that formed groups based on the simple ranking of each characteristic, a genetic algorithm was applied to strengthen the flexibility to multiple data sources (Flanagan et al., 2021). For each student, there is a corresponding vector covering multiple characteristics of the student for the calculation of fitness value (see Figure 2). These characteristics come from user model variables (Boticki et al., 2019) such as online reading logs, quiz scores from the LMS, and previous rating data from the peer evaluation module. Employing the fitness value, we can determine homogeneous groups that have similar members, or heterogeneous groups that are made up of dissimilar group members.

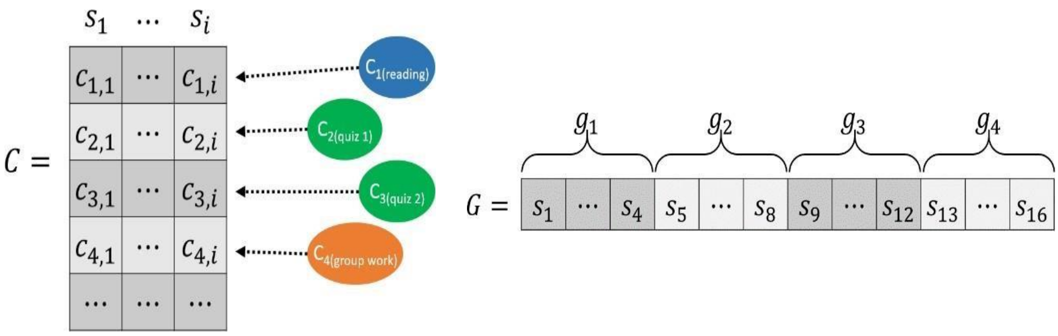

Figure 2. The mapping of student model variables to the characteristic representation matrix and group representation (Flanagan et al., 2021)

2.2 Continuous data-driven group work support

Figure 3 summarizes the continuous data-driven support throughout GLOBE that features the novelty of this study (Liang et al., 2022). This data flow provides an example of how to start with no existing learning logs in the student model initially and then incorporate the group work evaluations data cyclically for eventual group formation. Simple randomized grouping followed by using the evaluation score for subsequent grouping provides a feasible solution to the cold start problem in data-driven research (van der Velde et al., 2021). Such data iteration can also be used to identify students who may need special attention in the current group learning beforehand (Bukowski et al., 2017) in the detail panel of group formation results. Additionally, to determine the reliability of each evaluator's peer ratings, the student model attributes existing in the group formation system can be utilized as performance indicators according to Piech et al., (2013).

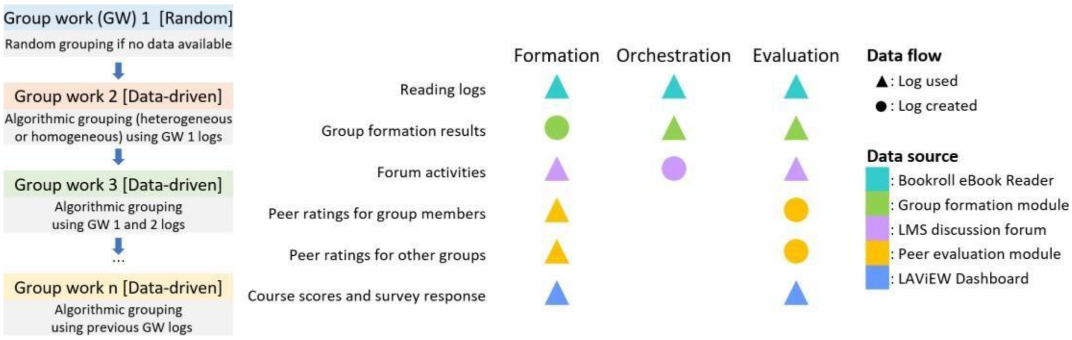

Figure 3. Continuous data feedforward of GLOBE (Liang et al., 2022).

3. Contributions to the field of CSCL and learning analytics research

This study provides a low threshold for the teacher to adapt the workflow thus promoting the use of a data-driven environment in actual class activities in several empirical studies. Previous implementations of GLOBE systems showed that it could reduce the time for teachers and students from trivial works of group formation and evaluation. Though we only used a few student model data in current studies, it disclosed further opportunities for the LA-enhanced group work orchestration following the continuous data flow, even in classroom-based contexts where no initial data existed. GLOBE implementation in other in-class learning contexts could be done with similar workflow, such as math problem-solving (Liang et al., 2021a) and English reading.

Though there have been studies discussing the impact of group compositions in actual group work (Janssen & Kirschner, 2020), this study contributes to digitizing this issue by introducing the heterogeneity value of each group which derives from the fitness value of genetic algorithm (Flanagan et al., 2021). We suggested a new perspective to explore how group composition on diverse student model data tends to make a difference in performance of subsequent phases. By investigating the specific student model variables for group formation, we can inspect the heterogeneity among which characteristics weigh more to affect the subsequent group work process and outcome.

4. Proposed research methodology

4.1 Algorithmic Group formation system in different learning contexts.

To address RQ1, we plan to conduct empirical studies on group formation using different student model data in various contexts. An implementation in Japanese primary school context was conducted. Engagement and affective states extracted by speech record were operationalized as group work indicators and suggest effectiveness of the group formation system (Liang et al., 2021a).

In subsequent studies, we aim to examine the flexibility of the group formation system in different scenarios to underscore its pedagogical implications. We shall fine-tune the system algorithm based on demand from different contexts. We are currently working on active reading in English learning which requires common reading markers as group formation criteria, and math learning that requires knowledge mastery models.

4.2 Continuous data support for the whole group learning process

As an organic component of GLOBE, group learning evidence can be used for group formation in subsequent rounds. We conducted a first trial of such a data feedforward approach across four sessions of in-class group discussion in a national language class in a Japanese middle school context where no student model data is available at first. The peer evaluation system (Liang et al. 2021b) was used to generate student models on group work experience for next-round group work. Peer ratings and group work perception surveys were adopted for evaluation of the group work performance.

The data-driven flow can not only benefit the group formation phase. For the evaluation phase, previous learning evidence can be used to determine the reliability of each evaluator. This will lead to another topic that focuses on the cultivation of peer evaluation capabilities across several rounds.

4.3 Ecosystem for automatic group formation with predictive indicators

Using the data of GLOBE implementation in different contexts, we can further explore which indicators can predict and determine the weight of each student model variable in group formation for different contexts (Janssen & Kirschner, 2020), and form an ecosystem to automatically recommend these indicators for teachers. Currently, we adopted factor analysis and correlation analysis to discover the relationships of indicators in all phases of GLOBE and highlighted key issues for successful group work in specific contexts utilizing current implementations of GLOBE systems.

In the next stage, as a closure of the loop between AI support and practice, we plan to transform parameter-based group formation to context-based group formation where groups can be automatically created using recommended parameter selection in line with learning context assigned by the teacher.

Acknowledgements

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Investigating The Impact of Modelling in a CSILE on Problem-Solving Strategies and Scientific Reasoning by Students in Complex Chemical Engineering Problems

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Abstract: Pre-college and first-year undergraduate students should be able to understand and reason using complex systems in science education. However, such novice students often lack the necessary knowledge or motivation and often rely on their epistemic heuristic reasoning strategies when understanding complex systems and solving complex problems. The use of such heuristics may lead to incorrect inferences as novices lack the simulation awareness for effectively using such strategies and move towards using analytical reasoning. Such awareness cannot be taught implicitly to students unless intervened by methods that help them reflect or test their solutions. Model-Based Reasoning (MBR) activities in Computer Supported Intentional Learning Environments (CSILE) like Knowledge Forum are one such way that I hope to promote such metacognition amongst novice students and scaffold their shift towards a more analytical reasoning approach. My research aims at investigating students' use of different reasoning strategies to make sense of complex chemical systems and related concepts and the ways in which CSILE together with models and simulations can scaffold them to collaboratively refine their epistemic heuristic reasoning strategies to more analytical strategies to solve complex engineering problems effectively.

Keywords: Heuristic reasoning strategies, CSILE, Knowledge Forum, analytical reasoning, complex systems

1. Rationale

Learning chemical sciences and engineering requires the ability to make correct inferences about the relative value of diverse physical and chemical properties of multivariate complex systems. To make such judgments, learners need to identify and discriminate between variables and their relevance in understanding the complex system and solving the related complex task (Maeyer & Talanquer, 2010; Talanquer, 2013). Reasoning and working with complex systems are challenging for students as they do not understand how different variables/components work in complex systems and often memorize parts and facts related to them (Feltovich, Coulson, & Spiro, 2001). Students also often use shortcut reasoning or *heuristics* that help them understand complex systems and solve complex tasks under uncertainty or in resource-constrained situations (Talanquer, 2013). In order to build knowledge and how to go about doing that, students use certain epistemic heuristics that guide student's reasoning in their scientific practises (Krist,2019). While experts carefully select and use such heuristics effectively, novices seldom pay attention to the heuristics used and end up with an inaccurate or incomplete conceptual understanding of complex systems and suboptimal solutions to complex problems. Reasoning about complex systems analytically is essential for the foundational understanding of many disciplines (Hmelo, 2006) thus making it imperative to scaffold students' effective use of heuristics and gradually transition them towards analytical reasoning. Heuristic strategies are considered to be automatic and unconscious thereby making it essential to train students metacognitively about ways to monitor their thinking skills so as to make better judgments in appropriate contexts (Maeyer & Talanquer, 2010). Making effective intuitive reasoning and allied strategies accessible to students can foster a better understanding of the concepts (Graulich, 2010). One way to help novice learners use such strategies would be through model-based reasoning (Won et al., 2014; Talanquer, 2013). By being able to create and manipulate the models and their variables, students can generate and refine their knowledge and understanding (Hallström & Schönborn, 2019; Magana et al., 2019). Computer Supported Intentional Learning Environments (CSILE) have been found to be useful for facilitating such creation and refinement of knowledge. However, their use for observing and refining heuristic reasoning, promoting metacognition, and gradually transitioning them towards analytical reasoning has not received much attention.

In my research, I intend to investigate the following - (a) students' use of different reasoning strategies to make sense of complex chemical systems and related concepts, (b) evolution of these strategies from heuristic to analytical when model-based and metacognitive scaffolds are provided, and (c) ways in which CSILE's knowledge building tools can be leveraged to scaffold the above two processes to enable students to collaboratively solve complex tasks effectively under uncertainty or in resource-constrained situations.

2. Literature review

Heuristic reasoning: Various studies on heuristic reasoning have identified students' reliance on the use of different types of epistemic heuristics--for example thinking across scalar levels, identifying and unpacking relevant factors, etc (Krist et al., 2019). A study showed how students themselves learned to develop a set of epistemic heuristics by engaging in scientific practises. This highlights how students understood heuristics and used them in building knowledge (Krist, 2016). Crosscutting Concepts (CCCs) as epistemic heuristics have been found to be useful while engaging in science and engineering practices like making sense of a new phenomenon. As epistemic heuristics are considered to be useful especially while making sense of a new phenomenon, CCCs can be thought to contribute to those practises by identifying productive questions and goals, supporting analogical reasoning, etc (Fick, 2019). This prior research acknowledges the use of epistemic heuristic strategies by novice students but do not focus on making these explicit and evolve into analytical reasoning strategies. Thus, while there's a need to make such heuristics visible noticeable to the students, there is a lack of research focusing on the same (Graulich,2010; Graulich,2015).

Model-based reasoning: Models are considered to be simplistic representations of the world but what aspects of the real world are considered necessary to be represented is left to the representer (Giere, 1988). Scientific modeling helps novice learners visualize and reason about their understanding of complex processes. Thus, creating and using models as explanatory and inquiry tools during the problem-solving process helps students engage in scientific inquiry and externalize heuristic and analytical reasoning used during the process (Baumfalk, 2019). While existing research highlights the usefulness of model-based reasoning for promoting scientific inquiry, very little insight exists into the use of models for helping students reflect on the epistemic criteria used by them for creating good scientific models and move towards analytical reasoning.

CSILE: Simulation-based environments allow students to interact and manipulate the scientific variables by changing input variables while they observe different graphical and visual representations of the complex scientific phenomenon (Sarabando et al., 2014). This collaborative interaction with the complex system allows students to develop higher-order thinking and research skills; crucial skills for understanding unobservable real-life phenomena (Chang et al., 2008; Koh et al., 2010). Prior research highlights how simulation-based learning might facilitate greater metacognitive self-regulation in students, helping them become aware of their choices and alternate conceptions. I plan to leverage one such environment, Knowledge Forum, to help make the students become aware of their use and appropriateness of the heuristic strategies. This is expected to allow us to make the students become aware of their use and appropriateness of the heuristic strategies in a collaborative way.

3. Research Questions

- How does a complex problem-solving task in a collaborative forum affect students' reasoning strategies in problem-solving of chemical concepts?
- How does creating models for interpretation scaffolded with metacognitive prompts and simulations for a chemical problem-solving context impact students' shift toward analytical thinking?

4. Theoretical Perspective

Our research is based on the theories of the mental model theory of logical thinking, dual process reasoning, and the theory of knowledge building. The theories of mental model theory of logical thinking believe that people can reason and reach conclusions without having complete knowledge or applying rules of logical reasoning. The learner compares the external premise with the analogous internal representation which was created as a result of basic semantic knowledge and then decided on changes (Johnson-Laird, 1989). This idea is also supported by research from Cognitive Science and Educational Psychology that talks about the dual process of reasoning (heuristic-analytical reasoning) where the heuristic step analyses for appropriate cues which are then used by the analytical process to make inferences (Evans, 1984). The knowledge-building theory is based on the principle of social constructivism and constructionism where a community of students shares a collective responsibility of working towards building their understanding of a chosen topic. Idea improvement is the basic premise of the theory and practice of KB (Scardamalia & Bereiter, 2006). Based on these three theoretical perspectives, I consider epistemic heuristics as "ideas" that get may get generated initially due to lack of complete knowledge about the complex system but get iteratively improved collaboratively over a duration of time with the help of evolving analytical reasoning.

5. Research Methodology and Study Details

The participants in my studies are pre-college and first year undergraduate students of chemical engineering. The study would be conducted in groups of 3-4 students in a collaborative set up in a CSILE, Knowledge Forum, so that the implicit reasoning strategies can be visible for interpretation in a shared environment. Models in this study are referred to the explanatory representation that is built as a result of knowledge building by students during their problem-solving process. Simulations are given to the students as part of their knowledge building process to help them in validating their sense-making process. A set of metacognitive prompts would be provided to the groups at the end of each iteration of their models. These prompts can be in the form of researcher's metacognitive questioning or check points inserted in the form of scaffolds in Knowledge Forum.

Pilot research: A pilot study was done (without a CSILE) with 7(M=6, F=1) pre-college students online during the Covid-19 pandemic. The students were asked to position themselves as heat engineers to rebuild the heat shield so that the Columbia shuttle disaster could have been avoided. The study spanned over 3 days during which they reflected on their strategies using a set of reflective prompts in a journal. This study shows a way of problematizing and refining common sense and alternate conceptions using simulations in the context of chemical education. The heuristics arising because of these alternative conceptions became more visible to the students when they started testing their proposed solutions in the heat transfer simulations on Molecular Workbench as also demonstrated in Chang et al., (2008). Additionally, the group discussion also helped them get multiple perspectives for solving the problem and refine the heuristics. Two types of students **(A):** Students who realize errors in their solutions, are aware of the heuristics used to lead to the erroneous outcome and embark upon refining their solution into an optimal solution **(B):** Students who realize errors in their solutions, are not aware of the heuristics used that lead to the erroneous outcome, and do not refine their solution were found during the study.

Future study: Findings from the pilot study provide key insights that can help the future investigation of the differences in the reasoning processes between the two types of students. The findings also inform how simulations can be used for increasing the metacognitive competence of motivated students in their use of heuristic reasoning. The future study is positioned in a CSILE to help us better understand the student reasoning processes while collaboratively solving a complex problem. . Knowledge Forum provides scaffolds in the form of prompts and a drawing environment to build new theories and engage in refinement within communities of students. Knowledge Building focuses on and encourages the notion of improvable ideas and how every idea should be critiqued and improved with better reasoning to advance the knowledge (Caswell & Bielaczyc, 2002; Scardamalia & Bereiter, 2014). The collaborative setup will enable students to engage in argumentation that would help them construct, revise and evaluate their explanatory models (Chin. C, 2010). Data collected would include models made by students, intermediate concept maps and theories in Knowledge Forum, post-activity interviews, and final solutions to the complex problems. This research aims to contribute to the existing research on student use of reasoning strategies in model-based reasoning and problem-solving of complex systems in chemical sciences.

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Digitally Enhanced Active Reading in a Learning Analytics Enhanced Environment

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Abstract: Active reading (AR) strategies have learners challenge reading through deep engagement with the content to foster their independence and develop their performance and skills in reading. A number of studies have been conducted to examine the effectiveness of AR, yet there is no research that uses logs obtained from reading activities to scaffold and promote AR learning. Therefore, this study proposes to investigate AR from Learning Analytics (LA) perspectives. An e-book called BookRoll (BR) was used, and the logs obtained from the learning were visualized and shared as feedback. As part of it, we designed and developed Active Reading Dashboard (AR-D). In the framework of our LA-enhanced AR called Digitally Enhanced Active Reading (DEAR), AR experiments in language classes were conducted to reveal its effects. As a result, it was found that the process of AR could be visualized from learning logs, and DEAR could be applied in formal and informal learning contexts. The AR-D was found to influence learners' attitudes or perceptions toward reflecting on their own learning and striving to improve their reading strategies. As future work, continual implementation and verifying its application in different learning contexts are suggested. We shall also consider the importance of stakeholders' engagement in learning environments.

Keywords: Active reading, Learning Analytics, Learning Analytics dashboards, learning logs, e-books

1. Introduction

Reading is a complex process and in order to improve reading comprehension, it is essential to teach reading strategies and provide opportunities for practicing reading. It is said to have two styles of reading: passive reading (PR) and active reading (AR). AR urges learners to read a passage with a purpose or intention, while during PR learners just read word by word from the beginning to the end without any purpose or intention (Sun, 2020). AR shares ideas of cognitive reading strategies such as inferring from context, note-taking, marker use, and summarizing (Ahmadi, Ismail, & Abdullah,2013), and involves ideas of metacognitive strategies such as planning, monitoring, adjusting, and evaluating their own reading (Iwai, 2011; Israel, 2007). Many studies have shown the effectiveness of AR (Aziz, 2020; Khusniyah, & Lustyantie,2017). However, most of the research has been done based on paper texts. Currently in Japan, with GIGA school initiatives (MEXT, 2020), each student is provided one device, and e-books are used as textbooks in many schools. One of the advantages of using e-books is that we can obtain learning and reading logs. Analyzing logs enables us to understand and potentially support the AR strategies of students. However, regarding the effect of using e-books for AR learning, we did not come across any research that used learning logs to visualize and analyze the process of AR. Therefore, an e-book reading browser called BookRoll (BR) was chosen as our main reading platform for this study, since the logs of reading activities performed with BR can be visualized with analysis tools (Ogata et al., 2018). Functions in BR facilitate AR activities, and LA dashboards in the analysis tool enable learners to reflect on their reading-learning behavior. Teachers can monitor their students' reading performance and engagement, and give feedback based on what is visualized (Majumdar et al, 2021). Our study focuses on investigating the effectiveness of LA-enhanced AR which we call Digitally

Enhanced Active Reading (DEAR) and the development and implementation of the Active Reading Dashboard (AR-D). Through the several cycles of the experiments, we have modified and made improvements to the AR strategy and the dashboard in order to answer the following research questions:

1. RQ1: How can DEAR scaffold learners' reading performance and affect their reading-learning behaviors and engagement?
2. RQ2: To what extent can DEAR assist teachers' pedagogical approaches and interventions?
3. RQ3: To what extent can DEAR be applied in the various learning contexts?

2. Proposed Research Work

This study aims to challenge revealing the effect of DEAR and AR-D by following the steps:

Step 1: we aim to support cognitive and metacognitive strategies in AR mentioned earlier within the digital learning environment. Step 2: we aim to evaluate its effect.

BR is an e-book reader within the framework of the Learning and Evidence Analytics Framework (LEAF) system (Ogata et al., 2018). The LEAF system consists of a Learning Management System (LMS) to coordinate the learning activity, BR, Learning Record Store (LRS), and LA dashboards called Log Pallet. For this study, we designed and developed AR-D in Log Pallet in order to implement and visualize AR activities effectively and efficiently. Instructors can upload learning materials in BR, and students can read them using reading-facilitating functions such as markers and memos. Data from reading performed in BR, such as who, when, and how long learners viewed BR, which page they opened, how BR functions such as memos and markers were used, and what was written or marked are stored as logs and can be checked on the dashboards. Students use BR to perform AR, check the logs accumulated by learning, and reflect on their AR learning to improve their reading and learning motivation, reading performance, and skills. Teachers can make decisions on the subsequent actions and reflect on their teaching approaches by looking at the logs. We named this learning design Digitally Enhanced Active Reading (DEAR), and the cycle of DEAR is illustrated in Figure 1.

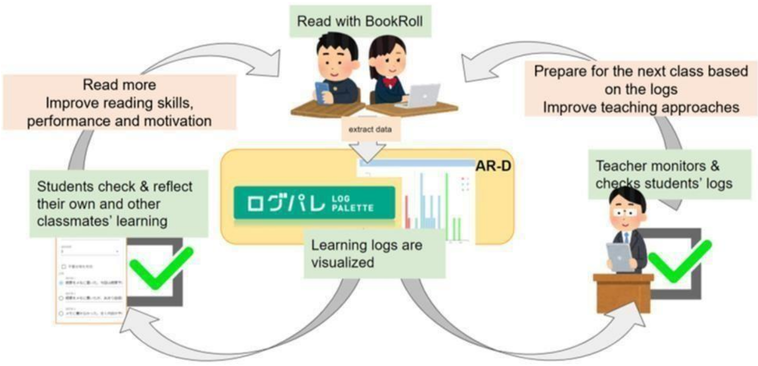

Figure 1. Conceptual framework of DEAR.

3. Methodology

The concept of Design-Based Research (DBR) was adopted for this study. DBR is an approach to validate the method in real-world settings with collaboration between researchers and practitioners, based on contextual design and theory (Wang, & Hannafin, 2005). We chose SQ4R (Survey, Question, Read, Record, Recite, Review) AR strategy as the fundamental of the reading theory. SQ4R is a reading procedure for efficiently understanding the content of the text (Khusniyah, & Lustyantie, 2017). Our research follows the cycle of the DBR principle: setting an objective and designing the method of an experiment based on the SQ4R theory, implementing AR with BR, analyzing the logs obtained from AR activities, sharing the logs with students and teachers, evaluating and giving feedback, reviewing the results, and setting goals for the next experiment. Based on the findings, we reviewed and modified the experiment designs and AR strategy. Regarding the AR strategy, we simplified and refined the SQ4R AR strategy to fit the current form of AR using BR and logs throughout the experiments. Based on it, AR-D was developed and embedded into LA dashboards to visualize each phase of AR. The process of an experiment with the DBR approach is illustrated in Figure 2.

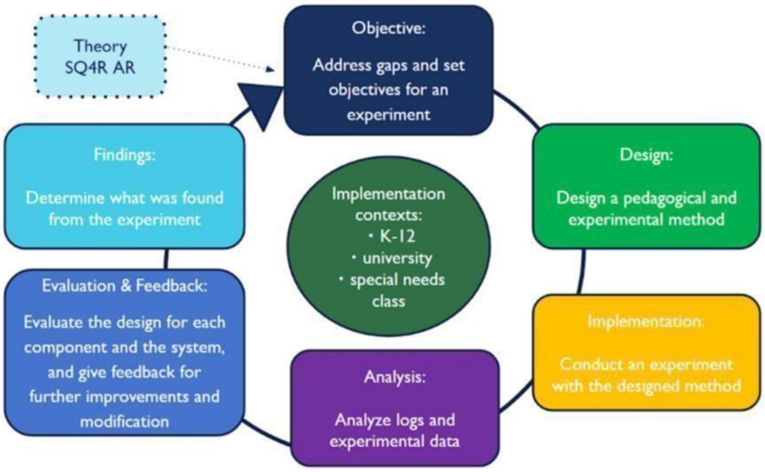

Figure 2. The process of an experiment based on the DBR approach.

So far multiple cycles of experiments were conducted in different learning contexts including junior high school, high school, and university English classes. Experimental designs include individual and group AR in class as formal learning settings and flipped learning as informal learning settings. Before and after each experiment, a pre-quiz for measuring participants' prior vocabulary knowledge and post quiz for their reading performance achievement were conducted. A pre- and post-survey were also conducted to obtain feedback from participants, such as impressions and opinions regarding AR, ARD, and BR and its functions. This research will include both quantitative and qualitative methods to collect data as shown in Table 1.

Table 1. *Experimental contexts, participants, and data sources for the research*

	Context	Participants	Data sources
High school 2020	English classes 1st and 2nd grade 5 days	76 1st grade (2 classes) 68 2nd grade (2 classes)	Logs from BR Pre and post vocabulary quizzes Pre and post surveys
College 2021	English AR class Freshmen 3 months	16 (1 class)	Logs from BR Pre and post quizzes Monthly and final tests Small group discussion Pre and post survey
Jr. high school 2021	English class 2nd grade 1 class	123 (3 classes)	Logs from BR Pre and post quiz Pre and post survey
High school 2021	English class 2nd grade 5 days	109 (4 classes)	Logs from BR Pre and post quiz Pre and post survey

4. Preliminary Findings

In the progress of our research so far, it was revealed that the process of AR was visualized by using BR which was not possibly done by using paper-books and e-books without analysis tools and LA dashboards. DEAR positively provided learning contexts in which not only learners could improve their reading performance and skills, but also allowed them to be aware of their own learning behaviors, reflect, and expand and deepen their learning. In addition, by using BR in flipped learning, the disadvantage of the learning approach in which it was difficult to visualize efforts of learning at home was resolved. Furthermore, it provided an environment for teachers to monitor their student's learning status, organize and adjust class content, and make decisions if any interventions are necessarily based on the logs.

5. Conclusion and Future Works

We have investigated the effects of DEAR and AR-D and the effectiveness of visualizing the reading process using LA dashboards. We still have some improvements to make. We have conducted experiments only in English classrooms; therefore, we shall consider other learning contexts besides language classes. Continual implementation is also required. We will proceed with research to make improvements based on the principle of the DBR while putting a value on stakeholders' engagement in evaluating learning designs and the system in order to meet individual learners' needs.

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Modeling Off-task Behavior of Learners Using Minecraft

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Abstract: This study presents an attempt to develop a detector of off-task behavior using the interaction logs of the learners in Minecraft. Text replays will be used to obtain ground truth labels of off-task behavior. Detectors will be built using a Latent Response Model, which predicts whether an action or event is off-task behavior and assess how frequently each of the students is off-task. The relationship between off-task behavior and students' learning outcome will also be examined. After developing the detector, a WHIMC module implementation will be conducted to apply intervention to keep the students from off-task behavior and to investigate how the learning outcomes will change after the intervention.

Keywords: Minecraft, WHIMC, Off-task Behavior, Intervention, Philippines

1. Introduction

Off-task behavior, in which a learner disengages from the learning environment or task to engage in an unrelated behavior, may affect students' learning (Baker, 2007). In a classroom setting, talking to other students about unrelated subjects and doing activities unrelated to the tasks are examples of off-task behaviors. Detecting this behavior in a classroom setting usually requires the use of sensors such as eye trackers and microphones (Baker 2007). Also, field observations such as the Baker Rodrigo Ocumpaugh Monitoring Protocol (BROMP) can also be used as a method to detect off-task behavior (Botelho, Baker, & Heffernan, 2019). Sometimes, sensors are not available and conducting field observations is not possible. Thus, interaction logs of the students within the learning environment are used to detect patterns of behavior (Kang, Liu, & Qu, 2017). However, detecting off-task behavior based solely on interaction logs is limited and is quite challenging since it varies in different learning environments (Carpenter et al, 2020).

This behavior has been associated with poor learning outcomes but may also aid students in regulating negative affect and returning to the learning task (Sabourin & Lester, 2014). With its impact on learning, there has been a growing interest to detect off-task behavior and examine how it affects learners' performance. Previous studies investigated off-task behavior in intelligent tutoring systems such as ASSISTments tutoring system (Botelho, Baker, & Heffernan, 2019; Pardos et al, 2014; Wixon et al, 2012), Cognitive tutor software (Baker, 2007) and in game-based learning environments such as Crystal Island (Carpenter et al, 2020; Sabourin & Lester, 2014).

The focus of this study is on off-task behavior in Minecraft, an open-ended sandbox video game. Open-ended games provide players autonomy on how to do the tasks in the learning environment, thus there is no prescribed learning sequence and analysis of behavior becomes significantly important (Käser, & Schwartz, 2020). With the open-ended nature of Minecraft, it is challenging to detect behavior patterns such as off-task behavior.

In this study, a detector of off-task behavior will be developed using the interaction logs of the learners in Minecraft. The relationship between off-task behavior and students' learning outcome will also be examined. This study would like to answer the following research questions:

RQ1: What features predict off-task behavior?
RQ2: How do off-task behaviors relate to the student's learning outcome?
RQ3: How will the learning outcomes of the students change after the intervention?

2. Review of Related Literature

2.1 Off-task Behavior in educational games

Games used for education can act as rich primers for engaged learning and were reported effective in improving learning outcomes (Zhonggen, 2019). The use of games in education attempt to form positive mood leading to increased interest in gameplay and better learning performance. The interaction logs of the learners within these games can be collected and analyzed to examine their behavior patterns and how it affects their learning (Kang, Liu, & Qu, 2017). One of the behaviors that may affect learning is off-task behavior, which is disengagement from the learning environment or tasks.

Previous studies investigated off-task behavior in different learning environments. A study (Botelho, Baker, & Heffernan, 2019) examined the data collected within the ASSISTments, a webbased tutoring system, to detect off-task behavior and affect and used quantitative field observations following the BROMP protocol for the ground truth labels. Both expert-engineered and machinedlearned features were generated for off-task behavior and affect using the log data and applied Naïve Bayes classifier, a REP tree classifier, and Long-Short Term Memory (LSTM). Another study (Pardos et al, 2014), that investigated off-task behavior in ASSISTments tutoring system, used an observation protocol to code affect and behavior. The off-task detector included the total number of attempts, time taken by a student to answer, if a student has a correct action, the average number of scaffolds, and the total number of incorrect actions in the past. They attempt to fit detectors using eight common classification algorithms including J48 decision trees, step regression, JRip, Naïve Bayes, K*, and REPTrees. The best detector of off-task behavior was found using the REP-Tree algorithm. Another study (Wixon et al, 2012), that investigated data from ASSISTments environment, presented a detector of the WTF "Without Thinking Fastidiously" behavior, in which the students were interacting with the software, but their actions appear to have no relationship to the intended learning task, which is related to off-task behavior. Text replays, a pre-specified chunk of student actions presented in text (Sao Pedro et al, 2010), were used to obtain ground truth labels of WTF behavior. Indicators of WTF include running the same trial a large number of times, pausing the simulation a large number of times, and changing variables many times without stopping to think before running the simulation. The detectors were fit using 11 common classification algorithms and the PART algorithm achieved the best performance.

Another study (Carpenter et al, 2020) used dialogue data collected from a group chat feature integrated into Crystal Island, a collaborative game-based learning environment for science, to investigate off-task behavior. Data was labeled by researchers using a rubric that was developed to identify on-task and off-task chat messages. The features used were the number of times the student had previously contributed to the group conversation, a score representing the polarity of the message's sentiment, the number of characters in the message, and the Jaccard similarity of the message with the game's text content, and the average word embedding for the message. They used logistic regression to perform binary classification of the messages. They also used an LSTM-based sequential model to analyze the sequences of data. The performance of logistic regression and LSTM were evaluated using accuracy, precision, and F1. Based on the results, sequential techniques for modeling off-task behavior outperform static techniques.

2.2 What-If Hypothetical Implementations in Minecraft (WHIMC)

What-If Hypothetical Implementations in Minecraft (WHIMC) is a set of simulations that learners can explore in order to learn more about science, technology, engineering, and mathematics (STEM). The alternate versions of Earth present learners with opportunities to observe the planet under altered conditions. Although the worlds are fictional, they are created in consultation with scientists: They accurately depict conditions on Earth under these circumstances.

In each of these alternate Earths and exoplanets, learners explore the terrain, describe the environment, report observations about how life on Earth is affected by these circumstances, and possibly create habitats that will enable them to survive. By immersing learners in these activities, WHIMC hopes to generate interest in and excitement for STEM among participating learners.

Previous studies analyzed the dataset from the module implementations in WHIMC which includes both in-game and out-of-game data. A previous study in WHIMC examined the relationship of features extracted from location data such as area, distance traveled, and MSI to assessment outcomes (Esclamado & Rodrigo, 2022). A study also analyzed and compared American and Filipino learner traversals and in-game observations against canonical answers from experts to determine the extent to which students achieved the desired learning outcomes (Casano & Rodrigo, 2022).

3. Contribution of the Proposed Research

This study contributes to the body of knowledge in 4 ways:

First, off-task behavior in Minecraft might be more difficult to detect because of the nature of the game. Open-ended games like Minecraft provide players autonomy on how to do the tasks in the learning environment, thus there is no prescribed learning sequence and analysis of behavior becomes significantly important (Käser, & Schwartz, 2020). With the open-ended nature of Minecraft, it is challenging to detect behavior patterns such as off-task behavior. In this study, the features that would predict off-task behavior will be identified.

Second, this will contribute to the literature on how off-task behaviors affect student's learning outcomes. This behavior has been associated with poor learning outcomes (Sabourin & Lester, 2014).

Third, since this study will also examine how off-task behavior relates to learning outcomes, this may provide an opportunity for a real-time intervention to guide the learners to better learning outcomes (Baker & Clarke-Midura, 2013).

Lastly, this will also contribute to the modeling of users in the Philippines, who tend to be underrepresented, since most studies are data from western learners.

4. Proposed Research Methodology

4.1 Data Collection

The data, consisting of in-game data and assessment data of WHIMC module implementations of partner schools in the Philippines, will be analyzed in this study. Partner teachers from the schools developed learning modules to explore the WHIMC worlds. The students then explore the WHIMC worlds based on the learning modules. After the exploration, the learners answer the knowledge assessments.

4.2 Off-task Behavior Detector

Log files will be converted to text replays, easy-to-read versions of the log files and are effective for providing ground truth labels for behaviors (Wixon et al., 2012). Human coders will examine the text replays and determine whether the actions or events are off-task behaviors. Using text replays, ground truth labels of off-task behavior for each action or event can be obtained.

Indicators of off-task behaviors in WHIMC are identified which include visiting other worlds when the task is not yet completed, not visiting the assigned worlds, visiting assigned worlds that need exploring for a very short time and/or only covering a very small area, not making observations, and not accessing the science tools especially if this is part of the learning task. Based on these indicators, features of off-task behaviors will be extracted from the log files.

RQ1: What features predict off-task behavior?

Detectors will be built using a Latent Response Model (LRM), which predicts whether an action is an off-task behavior and assess how frequently each of the students is off-task (Baker, 2007). Fast Correlation-Based Filtering and Forward Selection will be used to select the features and the model. Detectors will be assessed using metrics such as A', correlation, and kappa.

RQ2: How do off-task behaviors relate to the student's learning outcome?
Correlation analysis will be conducted between the number of incidences of off-task behaviors and the outcome assessment of the students to determine the effect of this behavior on learning outcomes.

RQ3: How will the learning outcomes of the students change after the intervention?
Another WHIMC module implementation will be conducted to apply intervention to keep the students from off-task behavior. There will be two learning modules that will be developed. In the first learning module, the learners will explore WHIMC based on the learning module and there will be no intervention yet. In the second learning module, there will be intervention to keep the students from off-task behavior. At the end of each module, there will be a knowledge assessment. The changes in the performance of the students in Modules 1 and 2 will be examined.

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