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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.

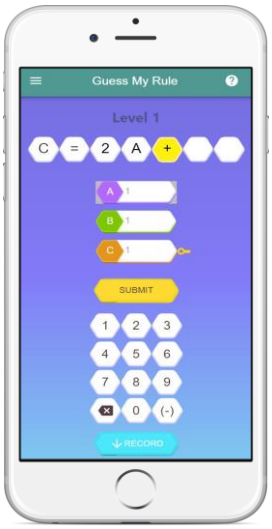

Figure 1. Code-solving Breakout Game

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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