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Two-way Knowledge Transfer Among University Academics, Young Entrepreneurs, NGOs and Students in STEM and IoT Metaverses: Conceptual Model, Research Agendas and Contextual Challenges

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Abstract: This paper presents an innovative metaverse design through collaborations among university academics, industry entrepreneurs, NGOs and students through a two-way knowledge transfer (KT) model. Unlike previous one-way KT approaches, this paper endeavors to formulate an interactive two-way KT conceptual model with evaluation of creative technological products, entrepreneur coaching programs and social caring services through (Arts/Green/Sports) STEM and IoT Metaverses. In the top layer of the KT model, one gigantic integrative network of academics, scientists and creative technologists work as a big data pool to provide high-tech professional knowledge. In the lower layers, collaborations among university academics, technology developers, industry entrepreneurs, NGOs and students work out knowledge-building community-of-practices using youth entrepreneur leadership models to develop technological products and provide services. For sustainability of knowledge transfer, educational / social funds will be used to support student activities financially. Participating young entrepreneurs care the elderly and disadvantaged people and develop their moral conscience during some STEM activities in empathic societies. Noteworthy, this paper presents five key features of decentralization, immersive properties, digital currency ecosystems (using blockchain technology), social experiences and persistency in the construction of met connecting real and virtual worlds. It also shows valuable learning experiences of participating students in STEM, game-based learning and IoT metaverses to testify the feasibility of knowledge transfer. Future research agendas in knowledge transfer in metaverses and contextual challenges will be addressed through action project reflection in the paper.

Keywords: Knowledge transfer, metaverses, STEM, IoT, action project

1. Introduction

Metaverse is a current and future integrated totality of the physical world and virtual world connecting internet-of-things (IoT) and other aspects of human lives with a wide range of applications of (wired / wireless) computer networks, handheld mobile devices, augmented reality / virtual reality / substitutional reality / mixed reality / extended reality (AR/VR/SR/MR/XR), artificial intelligence (AI) and robotics. Currently, metaverses provide a range of human imaginations and potential functionalities that enable new modes of e-business, e-trades, e-digital currencies and e-learning, and lots of immersive social and virtual experiences in STEM education and game-based learning (GBL). IoT and STEM metaverses refer to focused uses of internet-of-things (IoT) and STEM applications respectively into daily lives connecting the physical world and virtual world in metaverses. Proponents of metaverse education often pay heed to its virtual world construction but fail to pay close attention to the connections between physical and virtual worlds especially when some new technology is being applied into our daily lives (Hirsh-Pasek, *et al.* 2022). In this paper, an innovative two-way knowledge transfer model is implemented with evaluation in some IoT and STEM metaverses.

Previous knowledge management (KM) models aim to turn implicit knowledge into explicit knowledge, partly originated from Polanyi (1962)'s distinction between tacit and explicit knowledge. New KM emerging concepts in 1995-2005 include knowledge economy, knowledge alliance, knowledge culture, knowledge organization, knowledge infrastructure, and knowledge equity (Baskerville & Dulipovici, 2006). However, it is very difficult for KM and educational researchers to find out those socio-cultural mechanisms for transforming implicit knowledge into explicit one. Facing such problems, some KM researchers in school education would like to start firstly with KT from individual students' tacit knowledge and sharing of learning experiences in apprenticeship or mentorship through **S**ocialization; secondly, transforming from tacit knowledge to explicit one in group activities through **E**xternalization; thirdly, a **C**ombination (socio-cognitive synthesis) of existing explicit knowledge into new explicit knowledge; and fourthly, students' putting what they have learned into practices from their explicit knowledge through individual **I**nternalization by adopting traditional KM (SECI) models of Nonaka & Konno (1998), Nonaka & Toyama (2003). The two processes for knowledge entering and leaving the KT system are *assimilation* and *dissemination* respectively in organizational knowledge. There would be a strong potential of using some ICT innovations in virtual worlds (AR/VR/SR/MR/XR) and real world to make connections with those socio-cognitive features in the four-step spiraling processes of SECI interactions between tacit knowledge and explicit knowledge through metaverse construction. And KT should not be limited to teacher-oriented knowledge transfer (TKT) (like Peng *et al.* 2021) and student-oriented KT should have strong communal connections with other members of communities-of-practices beyond school education.

Knowledge transfer (KT) is more than learning. KT conceptually differs from knowledge sharing or knowledge dissemination, which was merely used for knowledge exchange between sources and recipients of knowledge. KT takes certain forms of information science and software engineering as knowledge reuse (Markus, 2001) but extends beyond the KM organizations' absorptive capacity to identify, assimilate and exploit knowledge (Alavi & Leidner, 2001). Previous KT models in school and workplace education have only one-way direction from high-level technical knowledge in industry or academics to students and teachers or very limited two-way interactions between academic institutions and the larger communities without direct, practical applications to schools. Therefore, there would be another strong feasibility of constructions of AR/VR/SR/MR/XR to connect with student knowledge transfer (SKT) to go beyond the scope of prior KT research studies through STEM and IoT metaverses.

2. Interactive Two-way Knowledge Transfer Model (See Appendix 1)

2.1 Importance of big data pools for provision of high-tech knowledge

In the top layer of the KF model, one gigantic integrative network of academics, scientists and creative technologists as a big data pool to provide high-tech professional knowledge. Without such content knowledge, KT cannot be initiated or updated as students need to obtain new professional knowledge directly from those experts and indirectly from university academics. In Web 3.0 metaverses, student learners are engaged into a variety of NFT STEM programs in the action projects. There are five underlying characteristics of IoT metaverse depicted in table 1.

Table 1. *Key features of metaverses and socio-cognitive functions in student activities*

Key Features of Metaverses	Socio-cognitive Functions in Two-way Knowledge Transfer (KT) model	Students' exemplified activities in IoT and STEM metaverses
Decentralized	Communal ownership enhances socialization and externalization in KT	Students learn Ethereum blockchain to understand the importance of communal ownership for e-trade transactions, tokens, e-marketing prices & bitcoins
Immersive	4-D / 5-D visualization facilitates members' embeddedness into metaverses for cognitive assimilation and dissemination in KT	Students' valuable 'immersive' properties can be actualized by their usage of AR glasses and VR/MR headsets with some multiple-role perceptions of ultra-realistic digital worlds in metaverses experiences
Digitalization	Monetization in digital currencies to	In digital currency ecosystems using

	build value systems of buying goods and consuming services in combination (cognitive synthesis) in KT	blockchain technology, students use e-cash coupons in AI shops to buy / sell products and services in T metaverses
Social experience	Gamification and STEM / IoT experiences builds empathized knowledge and moral conscience through internalization, externalization, socialization and combination in KT	Students exercise young entrepreneurship skills to produce new knowledge products and provide caring services to the elderly and disadvantaged people
Persistency	Accessibility without spatiotemporal constraints consolidates communal membership and further enhances socialization and externalization in KT	Students share their STEM / IoT experiences by interacting with other members without spatiotemporal constraints in STEM / IoT metaverses

There is a strong potential for metaverse members to be fully engaged in private and sharable communal spaces without possible threats posed by the pandemic (Hady, 2022). Such privacy and health security further enhances two-way KT.

2.2 Key features of metaverses and new educational directions of metaverses

The following features of IoT metaverses help foster socio-cognitive development of students and other key members of the two-way KT model. Some shortcomings of traditional collaborative learning communities-of-practices would not be found in IoT metaverses. Various types of knowledge transfer (KT) have been fostered and sustained by the following features of IoT metaverses (e.g. What is Metaverse? Step-by-step guide into the Metaverse, 2022):

- Awareness of ethical and legal concerns in members' social and moral responsibilities, data privacy, patent and intellectual property rights of members and products / services in metaverses
- Flexibility and diversities in all types of individual and social seamless learning, formal and informal education, (serious or causal) game-based learning (GBL) and non-game-based learning, academic discussions and experiential sharing (in videoconferencing, cloud phones, and online events platforms) and knowledge-building discourses anytime and everywhere
- Freedom earned in selection of learning and teaching modes, choices in real world (RW), virtual world (VW) and RW-VW, inviting or recruiting particular members or groups of members for interactions or accepting others' invitation or recruitment (allowing self-learning times and modes for deep or extensive learning)
- Transferability of information and sharing in single-, cross- and multiple-platforms in all types of PCs, handheld devices, dataloggers, mobiles, other PCs in wired / wireless networks, IoTs and so forth

2.3 Roles of NGOs in knowledge transfer

Being a good strategic partner in two-way KT, non-government organizations (NGOs) have played significant roles of catering for ongoing and ever-changing needs of local communities in flexible mode, creating innovative collaboration projects for diverse needs of schools and social service centers, providing realistic startup and meaningful youngsters internship opportunities through project collaboration, maintaining regular business relationships with technology vendors and social worker partners and connecting learning, course materials and learning tools with real industry. In some circumstances, NGOs perform more flexibly and earn more freedom for collaborators to explore than formal education partners in the perspectives of industry entrepreneurs and students in the aforementioned action projects (Institute for Social Innovation, 2022; Zbuchea *et al.,* 2019).

3. Action Research Design and Deliverable Products / Services

3.1 Overview of three cycles of action projects

The action projects run in ceaseless spiral cycles of 'planning-monitoring-evaluating' in two successive stages. *Stage 1:* initiating individual-, group and class-oriented IoT and STEM projects with stepwise evaluations and preparing for future development of related metaverses at micro-and meso-levels (one-way KT). *Stage 2:* connecting current projects and developing big-scale ones after stepwise evaluation, adjustment and modifications in current development of related metaverses at micro-and meso-levels (two-way KT)

In Stage 1, a series of innovative STEM programs and products have been delivered by the second and third authors in the following activities in table 2.

Table 2. *Learning Outcomes in STEM programs related to KT*

Programs or Stories Behind	**Learning outcomes (sharing links)**	**Aspects of KT**
1. Projection Mapping Prince Fat Shing@ The Education University of Hong Kong:	True love to share the STEM education experience of climbing up from the bottom of life: https://youtu.be/3mbIgWe5xHw	Sharing student learning experiences for promoting educational services in STEM education
2. Cyberport Tai Chi Pass vs MoCap Events	Co-organized school summer activities held after students completed the course internship https://youtu.be/F42LxaNzZ34	Actualizing Sports STEM into martial arts Tai Chi using student internship
3. AIR – AI Retail (Community Retail):	Students' usage of e-cash coupons in purchasing products and consuming services https://www.ictinpe.org/ai-ministore	Sharing student learning experiences in digital currency ecosystems
4. IGB – IoT Green BMS (Building Management System)	Students' awareness in Green education https://www.ictinpe.org/iot-classroom	Raising awareness in Green education and revolution in empathic societies

In Stage 2, several educational, social and industrial funds are being drawn to support a series of Blockchain and NFT STEM program which will be delivered to some needy students. For instance, the two-way knowledge transfer will take place when one young entrepreneur with undergraduate major in Blockchain technology delivers some lectures and conduct some instep training tutorials for a group of participating secondary school students.

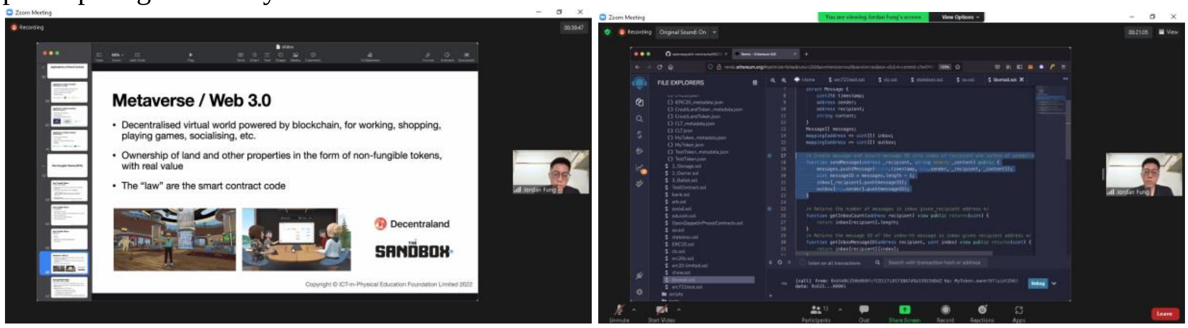

Figure 1 & Figure 2. Snapshots of one NFT STEM tutorial on metaverse and coding on blockchain

3.2 Nature of Collaborations Between Academics, Industry Entrepreneurs, NGOs and Students

In the two-way KT model, university academics provide professional research support, look for fund and co-organize coaching and training programs for participating students and young entrepreneurs. Industry entrepreneurs devise innovative technological products and services, launch coaching and training programs on new technology to needy students, and finetune or improve them after seeking valuable student feedback. Meantime, NGOs provide funding support, recruit young knowledge co-workers, provide career planning services, provide appropriate industrial resources (free space, connections with people and intern programs) for developing youth entrepreneurship models. Participating schools maximize students' other learning experiences (OLE) resources and applying for external grants to purchase necessary equipment and other learning resources.

3.3 Youth Entrepreneur Leadership Model in Metaverses

Past research literature on youth entrepreneurship focuses on social and cultural capital (Turner & Nguyen, 2005) and entrepreneurial resourcefulness (Quagrainie *et al.*, 2022). This paper presents another model using KT in metaverse education. During the implementation stages 1 and 2, proactive student leaders have played distinctive roles of creating innovative technological products in the business / industry sector, coordinating intern teams and supporting collaborations team works, nourishing moral conscience and positive / value education in entrepreneurship and providing caring services to needy (elderly and disadvantaged) people. Such traits exhibit a new young entrepreneur leadership model in metaverses, which is an under-researched topic in ICT education (c.f. training programs offered by Summer Discovery, 2022). Youth entrepreneurs use an intrinsic motivation to explore interested learning topics and invent creative technology products, and they learn by mistakes.

4. Future Research Agendas

Since the applications of metaverses in school and workplace education are still in an immature stage. Currently, there has not been any detailed cognitive or socio-cognitive international or local studies on using IoT and STEM metaverses in school and workplace education. After the first and second stages of the action project, some heated research agendas need to be addressed such as quantitative and qualitative measurement of knowledge transfer (KT), socio-cognitive aspects of KT in Arts / Green / STEM and IoT metaverses, socio-cultural and sociological issues like gender inequalities, parental motives for buying paid products and services from schools and industry entrepreneurs and curricular development of relevant blockchain application course modules to those needy students in Arts / Green / STEM and IoT metaverses

Challenges ahead include sustainability in subsequent / parallel development of various types of metaverses, continuity of funding support, professional accreditation of organized products and deliverable services, lack of academic / know-how knowledge in blockchain applications in school education and uncertain collaboration channels and unclear virtual world-real world connections.

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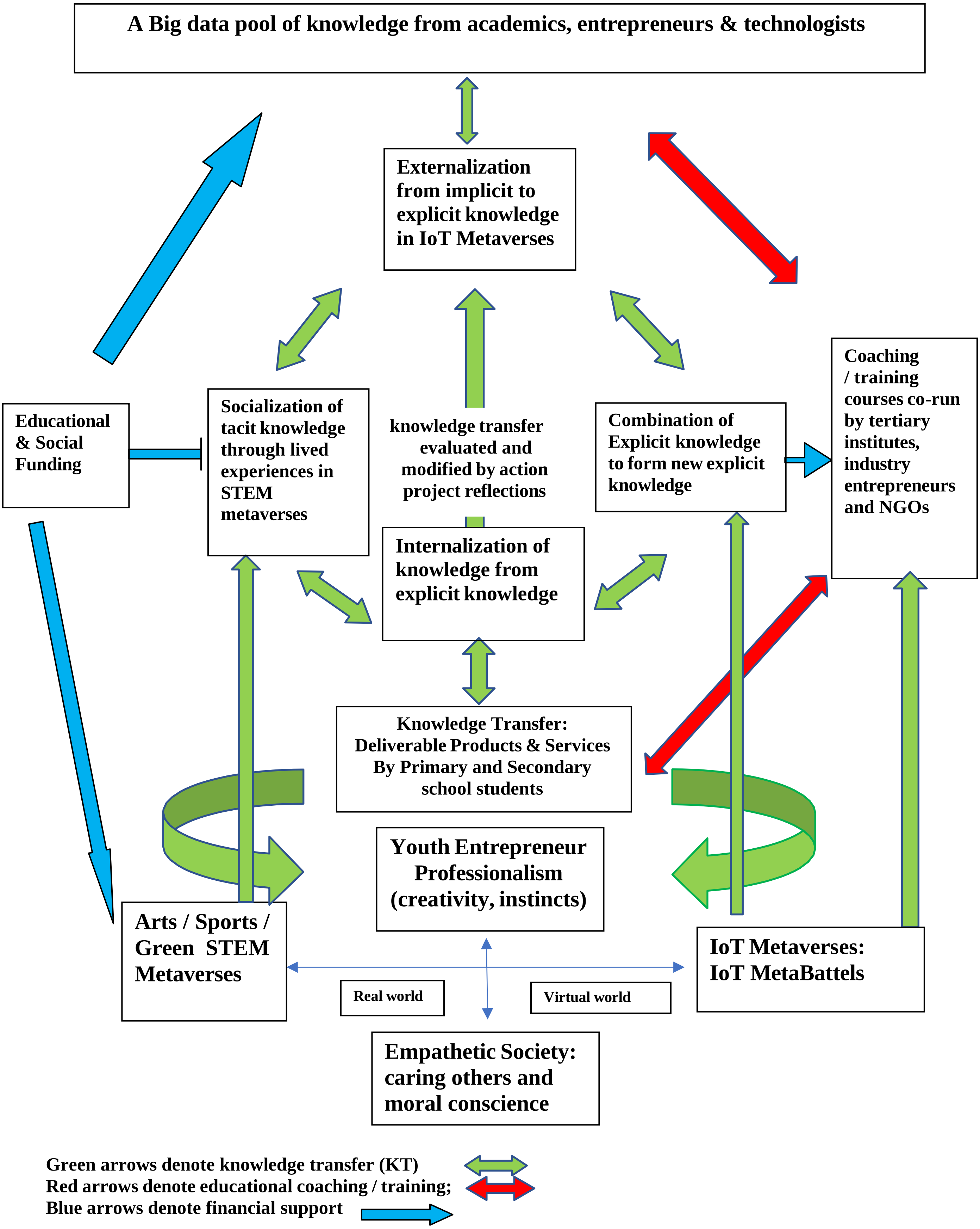

Appendix 1. A Multi-level Two-Way KT Model in STEM and IoT Metaverses