Transfer of Learning from Metaverse to Blockchain for Secondary Students: Implementation and Effectiveness Evaluation

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ABSTRACT

The cultivation of professionals and the fostering of awareness and literacy surrounding blockchain technology are indispensable because of its unprecedented impact on daily lives. However, the existing blockchain Teaching and Learning (T&L) approaches for secondary students are inadequate. In this study, we designed a tailored workshop for secondary students and examined the effectiveness of introducing blockchain concepts in the context of metaverse by implementation. The workshop integrated four educational theories, including Transfer of Learning, Interest Theory, Situated Learning, and Experiential Learning. The synthesis of typical theories gives rise to an innovative education strategy aimed at facilitating a transfer of awareness and interest from the metaverse domain to the blockchain domain, which is also the workshop's ultimate goal. The workshop was designed considering the developmental status of secondary school students and its alignment with the Hong Kong secondary curriculum framework to accomplish the learning objective of enhancing their knowledge, skill, awareness and interest in blockchain technology. 225 secondary students joined the workshop, and the findings demonstrated that our approach is effective and the adoption of the transfer from the metaverse domain to the blockchain domain is feasible. The results of this paper may serve as a successful example of blockchain education for secondary students.

CCS CONCEPTS

• **Social and professional topics** → Computing education; • **General and reference** → Empirical studies.

KEYWORDS

Blockchain, K12 Education, Transfer of Learning, Teaching and Learning

ACM Reference Format:
Alven C. Y. Leung, Zoey Ziyi Li, Dennis Y. W. Liu, Richard W. C. Lui, LUO Xiapu Daniel, and Siu Wo Tarloff Im. 2024. Transfer of Learning from Metaverse to Blockchain for Secondary Students: Implementation and Effectiveness Evaluation. In *Australian Computing Education Conference (ACE 2024), January 29–February 02, 2024, Sydney, NSW, Australia.* ACM, New York, NY, USA, 10 pages. https://doi.org/10.1145/3636243.3636260

ACE 2024, January 29–February 02, 2024, Sydney, NSW, Australia

ACM ISBN 979-8-4007-1619-5/24/01.
https://doi.org/10.1145/3636243.3636260

1 INTRODUCTION

Blockchain technology has become an essential innovation with profound implications across diverse sectors [3, 41, 52], including supply chain management [31, 49], education [2], and finance [22]. The adoption rate of blockchain keeps increasing [12, 23]. However, in contrast to other information technologies, blockchain is a novel and abstract concept for the general public. Therefore, there is an imperative need to arouse awareness and literacy, as well as cultivate professionals among the new generations.

Various blockchain T&L approaches currently exist, which include the courses offered by educational institutions and online platforms such as Coursera and edX, and have yielded significant T&L outcomes [11, 24, 38, 51]. Nevertheless, these approaches are generally designed for tertiary-level or typically require a fundamental understanding of blockchain. There exists a dearth of blockchain T&L approaches specifically designed for secondary students.

In order to mitigate the dearth of educational resources on blockchain and enhance the T&L process for secondary school students, a training workshop was conceptualized and developed. The workshop was designed for them to prepare for a metaverse competition held by a university in Hong Kong. With the goal of optimizing the effectiveness and attractiveness of the workshop, we employed the concept of metaverse as the entry point. The employment is justified due to its interchangeability with blockchain and high relevance to secondary students.

Metaverse is aimed to be constructed in a decentralized manner; Thus, blockchain emerges as the foundational technology, enabling the secure ownership and transfer of digital assets and data integrity assurance [54]. Blockchain and metaverse have a high relevance from technical perspectives, hence establishing their interchangeability from educational perspectives. Coincidentally, given the widespread exposure of secondary students to virtual realities or worlds, such as video games like Minecraft [5] and Roblox [19] and participation in virtual classrooms [20] and exhibitions [7], most of them tend to have a foundational understanding of the metaverse, which can act as a stepping stone for students to delve deeper into related technologies, such as blockchain.

The interchangeability and high relevance were leveraged to establish a T&L environment that facilitates the transfer of awareness and interest from metaverse to blockchain technology, which is the workshop's ultimate goal as well. This is accomplished by employing non-fungible tokens (NFT) as a medium bridging the concept of metaverse and blockchain. NFT is a realization of blockchain and functions as virtual assets within the metaverse [14, 54], which can help secondary students better grasp the knowledge about blockchain by applying their apprehension of metaverse.

The workshop integrates four educational theories, including Transfer of Learning, Interest Theory, Situated Learning, and Experiential Learning. Transfer of Learning and Interest Theory provides a theoretical foundation to construct the T&L environment, while Situated Learning and Experiential Learning offer students impactful learning experiences through practice. During the workshop, students will be given hands-on experience to expand their knowledge, skills, and awareness of blockchain through interacting with NFT. Additionally, the workshop was designed considering the developmental status of secondary school students and its alignment with the Hong Kong secondary curriculum framework to result in significant learning outcomes.

The workshop's implementation serves as an empirical study with the objective of answering the following research questions:

(RQ1) Is metaverse a good entry point for blockchain education for secondary students?
(RQ2) Can the workshop cultivate students' interest in blockchain?

This paper is organized as follows. The review of existing T&L approaches for blockchain will be provided in Sec. 2. The relationship among blockchain, metaverse and Web3 will be introduced in Sec. 3. Detailed information about the design of the workshop will be presented in Sec. 4. The research methodology will be introduced in Sec. 5. The findings will be evaluated in Sec 6.

2 EXISTING BLOCKCHAIN T&L APPROACHES

In light of blockchain technology's increasing acceptance and importance, several T&L approaches for blockchain are being developed and are presently accessible. Generally, these approaches can be categorized into traditional classroom-based and Massive Open Online Course (MOOC).

Some educational institutions offer traditional classroom-based approaches to educate blockchain, primarily targeting tertiary-level students specializing in a particular major. One example is a blockchain T&L approach specifically designed for graduate students majoring in accounting [24]. A code-based method is applied in this approach to enable the students to acquire blockchain knowledge and skills through hands-on programming experience. An alternative example approach is using a blockchain course to educate graduate and undergraduate students in accounting and other business disciplines [51]. This approach employs traditional teaching methods and case study activities to instruct students on fundamental blockchain principles, including cryptography, cryptocurrency, and distributed ledger technology. Although the approach is effective and feasible, it is unsuitable for secondary students when considering the course prerequisites, complexity, and personal maturity.

MOOC platforms like Coursera and edX provide several blockchain courses, most of which are offered by reputable organizations such as IBM, Linux Foundation, and universities worldwide. The courses range from introductory to advanced levels, as well as the contents are of a wide variety, covering basics, applications, implementation, ethics, and security. It provides learners the flexibility to select the course that aligns with their expectations. During the T&L process of MOOCs, learners will engage by watching a series of videos. Certain courses require learners to complete assignments, such as quizzes, programming tasks, and peer evaluations, in order to strengthen and guarantee learning performance. However, MOOCs require self-discipline and a lack of interaction compared to traditional classrooms. Furthermore, the contents of existing blockchain MOOCs do not particularly target secondary students.

Regardless of their forms, the approaches are typically designed for tertiary levels or adults and generally require a basic understanding of blockchain-related subjects such as computing and finance. There is a limited availability of blockchain T&L approaches for secondary students, which provided a motivation for this research.

3 THE RELATIONSHIP AMONG BLOCKCHAIN, METAVERSE & WEB3

3.1 Technical Perspective

Blockchain is a technology that functions as an advanced database mechanism, offering decentralized operations, ensuring data immutability, integrity and traceability [14, 44, 58]. Its characteristics can facilitate and streamline business processes across diverse organizations [1, 9, 53]. On top of it, it realizes Web3, a new web generation concept allowing web users to connect to the decentralized network [15, 28, 36], granting them greater capacity to control their ownership [6, 47]. Web3 offers enhanced privacy, security, and sovereignty to web users [4, 55]. By capitalizing on these benefits, metaverse is built by integrating with other information technologies such as Virtual Reality (VR), Artificial Intelligence (AI), and the Internet of Things (IoT) [35, 54, 56]. Metaverse provides web users with a virtual world in which they can experience an immersive reality [30, 54]. Currently, metaverse serves as a competent digital environment across various sectors such as education [18], tourism [8, 16], and healthcare [10]. The adoption of metaverse provides numerous benefits, including global interactions' enhancement, social media platforms' upgrade, online T&L improvement, and commercial opportunities' creation [8, 10, 16, 18, 29, 42].

Figure 1 summarized the relationship among blockchain, metaverse and Web3, and their common technical components [14, 15,

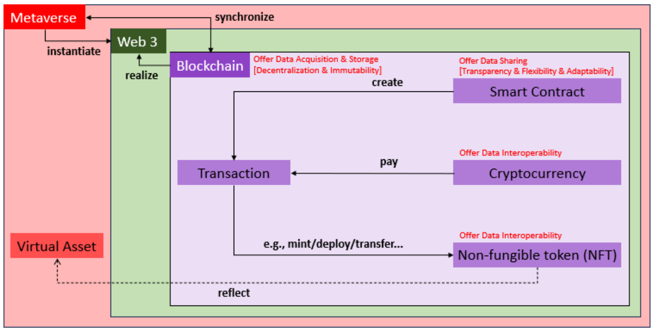

Figure 1: The relationship among blockchain, metaverse and Web3, and their common technical components.

35, 37, 54]. Web3 is a concept connecting blockchain and metaverse. Metaverse is an instantiation of web3, like the relation of an object and a class in the computing programming paradigm. Besides, blockchain and metaverse have an inseparable relationship. The products of blockchain (e.g., smart contract, cryptocurrency, and NFT) provide functionalities including data interoperability, sharing, acquisition, and storage inside the metaverse. These functionalities are integrated with other information technologies for the creation of new functionalities in metaverse. For example, NFT serves as a representation of virtual assets (e.g., 2D/3D objects) in metaverse.

3.2 Educational Perspective

Blockchain, metaverse and Web3 are highly relevant from technical perspective. Due to their relationship, these three topics share common components from educational perspective.

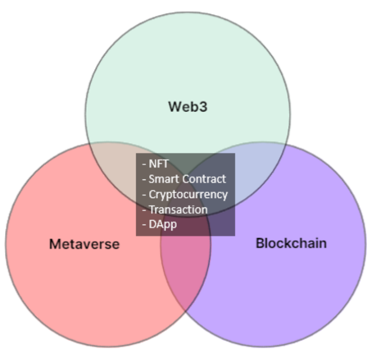

Figure 2: Venn diagram of the relationship among blockchain, metaverse, and Web3 and relevant components in educational perspective.

When instructing these topics, NFT, smart contract, cryptocurrency, transaction, and DAPP are usually mentioned since they are the products of blockchain and are the facilities to represent entities and their operations in metaverse and Web3. Hence, there is an intersection among these topics from educational perspectives, which allows transiting from one topic to another within the T&L process. This research proposes a T&L approach to introduce blockchain to secondary students by choosing metaverse as the entry point and NFT as the medium (i.e., NFT hands-on workshop). The workshop helps student first have a concrete application scenario of blockchain so that they will have more incentives to explore related concepts and develop their skills in blockchain. By doing so, it is possible to foster the development of future generations of blockchain professionals. The workshop also provides proper concepts of NFT and blockchain to secondary school students, equipping them with the necessary understanding to mitigate any risks associated with NFT and blockchain, such as scams.

4 THE WORKSHOP

4.1 Strategic Design

According to the instructions outlined in the Secondary Education Curriculum Guide issued by the Education Bureau of the Hong Kong Special Administrative Region (HKSAR) [39], the inclusion of blockchain as a study topic within the curriculum of core or elective subjects, including "Information and Communication Technology", "Business, Accounting and Financial Studies", "Technology and Living", and "Citizenship and Social Development", in secondary schools in Hong Kong is not compulsory.

However, the guide proposed a School Curriculum Framework (SCF) for secondary schools to serve as a reference and emphasize the curriculum's learning objectives. It includes fostering Whole-Person Development (WPD) through the implementation of Life-wide Learning (LWL). LWL refers to the educational method wherein students engage in real-life scenarios and authentic settings in order to achieve learning objectives that are more challenging to attain within the boundaries of traditional classroom settings. In secondary schools, LWL is implemented within the T&L framework of each Key Learning Area (KLA), encompassing cross-curricular studies and various extracurricular contexts. The eight KLAs in secondary education comprise "Chinese Language", "English Language", "Mathematics", "Personal, Social and Humanities", "Science", "Technology", "Arts", and "Physical". Furthermore, The integration of information technology in Interactive Learning has been identified as one of the Four Key Tasks in SCF, serving as a strategic approach to foster the development of students' learning-to-learn capacities inside and beyond KLAs. Hence, in accordance with the HKSAR's SCF and recognizing the importance of blockchain technology, our blockchain workshop for secondary students integrates four educational theories: Transfer of Learning, Interest Theory, Situated Learning, and Experiential Learning.

In a metaverse competition for secondary students held by a university in Hong Kong, we employed the concept of metaverse as an entry point to introduce the blockchain to the participating students. Metaverse is an application that facilitates the manifestation of virtual reality and virtual worlds. Moreover, it has been recently encountered by numerous secondary school youngsters in various forms. The experience fostered their consciousness and curiosity. Building upon that foundation, we applied the Transfer of Learning and Interest Theory to design a workshop aimed at transferring their awareness and interest from the metaverse to blockchain.

In addition, in order to enhance the effectiveness and attractiveness of the workshop, we implemented Situated Learning and

Experiential Learning theories by creating a dedicated T&L environment where students could participate in hands-on tasks and acquire knowledge and skills through first-hand experience.

A concise introduction and elaboration on the implementation of four educational theories within a workshop setting are provided below:

- **Transfer of Learning**: Transfer of learning proposes that knowledge can be transferred in distinct but relevant domains depending on the common element [17, 43, 57]. For example, having skills in playing the violin can accelerate the learning process of playing the piano since both skills have a common element (i.e., music) [59]. This workshop applies this theory to transfer awareness and knowledge from metaverse to blockchain by which metaverse and blockchain have common elements from technical perspectives. The type of transfer utilized in this workshop is Positive Transfer, which refers to a transmission when the original acquisition of knowledge or skills can positively lead to learning impacts in related domains [43].
- **Interest Theory**: Interest can be classified into two types, which are Personal Interest (PI) and Situational Interest (SI) [46]. PI refers to an individual's long-term psychological disposition having attention to a particular domain, while SI is short-term and based on environmental factors that spontaneously arise [21, 40, 45, 46]. Additionally, a research [34] successfully demonstrated that it is possible to convert prior PI to SI in different domains within the same academic discipline. This workshop makes use of this theory and references the prior research to establish a T&L environment to convert the students' PI in metaverse to SI in blockchain and eventually create a situation where the students can sustainably develop their PI in blockchain.
- **Situated Learning**: Situated Learning states that learning experiences provide beneficial outcomes when they are positioned inside a contextual environment, as well as participation and social interaction within a situated environment provide a platform for students to acquire knowledge and skills [13, 32, 33]. This workshop applied this theory to construct a situated learning environment using blockchain, metaverse, and NFT. Given the context of metaverse, students study the concepts of blockchain through the interaction with NFT.
- **Experiential Learning**: Experiential Learning refers to a pedagogy in which students acquire knowledge and skills by involvement in practical tasks and reflection from experimentation [26, 50]. Several studies have indicated that the proper application of this theory can lead to substantial educational achievements in the fields of technology [25, 27, 48]. This workshop applied this theory, offering students experiential tasks to interact with NFT, enabling them to grasp the ideas of blockchain effectively.

4.2 Objectives

The ultimate goal of the workshop is to establish a T&L environment that facilitates the transition of secondary students' awareness and interest from the metaverse to blockchain technology.

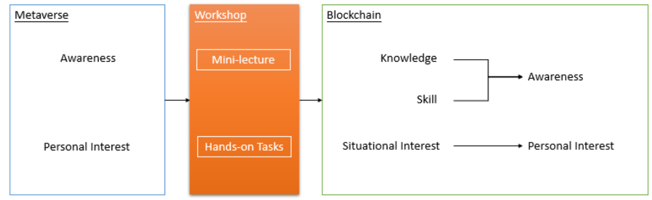

Figure 3: Overview of workshop ultimate goal

The workshop was designed to leverage the students' awareness and personal interest as a means of attracting their participation. The workshop consists of two separate sections: mini-lecture and hands-on tasks. The objective of the mini-lecture is to provide students with essential knowledge regarding the concepts of metaverse and blockchain, facilitating the development of a fundamental understanding of the practical task section. Additionally, the hands-on tasks aim to enable their skills in dealing with NFT, as well as associated components like crypto-wallets, cryptocurrencies, and smart contract. By participating in the workshop, students will acquire the knowledge and skills related to blockchain. Additionally, their engagement in the workshop may foster a situational interest in the subject matter. Subsequently, the acquisition of knowledge and skills can transform into awareness, while situational interest has the potential to evolve into personal interest, thereby fostering the development of future professionals in the field of blockchain.

Moreover, the workshop is designed to accomplish the following learning objectives:

- **Awareness**: Build up students' awareness of blockchain.
- **Knowledge**: Introduce to students the principles (including definition, operation, and structure) and applications of blockchain in metaverse.
- **Skill**: Develop students' practical skills in NFT (including create, deploy, mint, and trade).
- **Interest**: Enhance students' interest in blockchain technology.

4.3 Content

The workshop is offered to secondary students who joined a metaverse competition, organized by a computer science department of a university in Hong Kong to allow them to eventually apply the concepts of blockchain in the application they would build for the competition. The total duration of the workshop is three hours. Students were introduced the fundamental concepts of blockchain and its relationship with metaverse by a mini-lecture at the beginning of the workshop covering the following topics:

- Blockchain? What and Why?
- Blockchain: A Distributed Ledger
- Blockchain 1.0: Cryptocurrency
- Blockchain 2.0: Computability
- Blockchain-based Applications
- Gaming and Metaverse
- Roles of Blockchain in Metaverse

They were then given hands-on tasks pertaining to cryptocurrency and NFT. There are eight essential hands-on tasks as shown in Table 1.

Table 1: Hands-on tasks in the workshop.

Task Code	Task	Content
T1	Set up an online (decentralized application) DApp template	Set up a DApp template using an online Web3 development tool.
T2	Set up a crypto wallet	Set up a crypto wallet, switch to a testnet, receive cryptocurrency, and eventually check account balances.
T3	Deploy NFT smart contract	Edit global environmental variables of the NFT smart contract. Compile and deploy the smart contract..
T4	Store image files to Interplanetary File System (IPFS) and compose the NFT metadata	Set up an image as an NFT 2D asset, then upload it to IPFS and configure its metadata.
T5	Mint NFT	Configure and run an NFT minting script.
T6	Add NFT to crypto wallet	Add the minted NFT to students' own crypto wallet.
T7	Trade NFT at marketplace	Import NFT to a marketplace and list it for sale. Purchase other participants' NFT in the marketplace.
T8	Create 3D NFT objects	Create 3D object. Mint and list it in marketplace for sale.

The instructor provided step-by-step guidance to students in completing T1 to T7. T8 serves as a review exercise that the students have to complete by themselves. T1 to T7 is the comprehensive procedure spanning from the initial setup to the activation of trading for NFT. The guidance from an instructor is necessary as it operates under the assumption that the students have no previous experience regarding the manipulation of NFT. Upon following the first experience (i.e., T1 to T7), the students are expected to demonstrate proficiency in applying their acquired skills. Therefore, T8 is assigned as an individual exercise in assignment for deepening and evaluating the skills just acquired.

Table 2: Task Dependencies on Software and Tools.

Software & Tools	Description	Associated Tasks
Alchemy	Web3 developer tools	T1, T3, T8
Etherscan	Blockchain explorer for Ethereum	T3, T5, T8
Hardhat	Development environment for Ethereum software	T3, T8
JavaScript	Programming language for managing smart contracts	T3, T5, T8
JSON	Standard text-based format for setting global environmental variables	T3, T5, T8
MetaMask	Crypto wallet platform	T2, T6, T7, T8
OpenSea	NFT marketplace	T7, T8
Pinata	IPFS service provider	T4, T8
Solidity	Programming language for implementing smart contracts	T3, T8

In addition, the workshop requires students adopt various software and tools to complete the tasks. Table 2 shows the task dependencies, regarding the software and tools required.

Engagement in hands-on tasks may encourage the acquisition and refinement of practical skills in NFT among students. They are supposed to acquire an in-depth understanding of the complete processes involved in the entirety of the procedure, starting from the initial setup and ending in trading for an NFT. Additionally, they can acquire the skill to utilize the software and tools' dependencies employed in the workshop. This expertise is going to be advantageous in their future endeavours with the development of metaverse and blockchain applications from a technical perspective.

5 METHODOLOGY

A mixed-method approach is employed in this study, incorporating several data collection instruments including pre- and post-quiz, pre- and post-questionnaire, and assignment. The pre- and post-quiz comprise seven True, False, or Not Sure questions related to NFT, intending to assess the level of comprehension of NFT among the students before and after the workshop. Moreover, pre- and post-questionnaire were utilized to assess the level of awareness, knowledge, skill, and interest before and after the workshop, as well as to collect comments and evaluate participant's satisfaction with the workshop. The pre- and post-questionnaire comprised 26 questions, while 24 questions were paired between the two questionnaires (Appendix A). Pre-quiz and questionnaire were distributed at the beginning of the workshop, whereas a post-quiz and questionnaire were distributed at the end. Students were also given an assignment consisting of five review questions and two hands-on exercises. The submission of the assignment is not compulsory. However, it serves as one of the assessment items of the metaverse competition. The submissions were graded by the academic staff of the department. The total mark of the assignment is 100. The performance of the assignments contributes to the evaluation of the workshop's effectiveness.

Table 3: Adopted research methodology and analysis methods.

Research Method	Type	Analysis Method(s)
Pre-& post-quiz	Quantitative	Comparative analysis Descriptive analysis
Pre-& post-questionnaire	Qualitative, Quantitative	Comparative analysis Content analysis Descriptive analysis Holistic grading
Assignment	Qualitative, Quantitative	Descriptive analysis Holistic grading

Four types of data analysis methods are adopted in this study, including comparative analysis, content analysis, descriptive analysis, and holistic grading:

- **Comparative analysis**: Produce reports of paired-samples t-test and effect size (Cohen's d), aiming to assess the difference (including awareness, knowledge, skill, and interest) between before and after the workshop.
- **Content analysis**: Use the Topic Modeling method to classify the responses from open-ended questions, and generate a frequency distribution table. The objective is to assess what the students learned from the workshop and the feedback.
- **Descriptive analysis**: Produce demographic statistics to assess the degree of satisfaction with the workshop and the secondary students' awareness regarding blockchain and NFT.
- **Holistic grading**: Evaluate the understanding of blockchain, metaverse, and NFT among students, as well as their academic achievements.

6 RESULTS AND FINDINGS

6.1 Demographic

The workshop was implemented as a part of a non-compulsory training program for a metaverse competition at a university in July 2023. There were 225 students from various secondary schools. The pre-questionnaire had 142 responses, while the post-questionnaire had 44 responses. A total of 34 paired samples were retrieved from these questionnaires. Table 4 displays the demographic statistics of the workshop.

Table 4: Demographic of Workshop Participants.

	Division	Frequency
Gender	Female	48 (33.8%)
	Male	94 (66.2%)
Current Year	Secondary Three (age 14-15)	5 (3.5%)
	Secondary Four (age 15-16)	74 (52.1%)
	Secondary Five (age 16-17)	61 (43%)
	Others (age 12-14, 17-18)	2 (1.4%)
Currently Studying Elective Subject	Biology	22 (15.5%)
	Chemistry	22 (15.5%)
	Economics	28 (19.7%)
	Information and Communication Technology (ICT)	101 (71.1%)
	Physics	32 (22.5%)

The item "Others" in "Current Year" is referred to as Secondary One, Two, and Six. Secondary students in Hong Kong may study multiple elective subjects. Elective subjects, including Geography, Visual Arts, Tourism and Hospitality Studies, and History, with low frequencies (<13) are not displayed in the table.

Demographic statistics' results indicate that the workshop participants exhibit diversity in terms of gender, studying year, and discipline. More precisely, the gender distribution is skewed towards males, with a higher representation than females. Moreover, most of the participants are studying Secondary Four or Five, which amounts to more than 95%. Besides, the majority of participants are currently studying STEM-related subjects, while 70% of the participants are currently studying ICT.

6.2 Preunderstanding

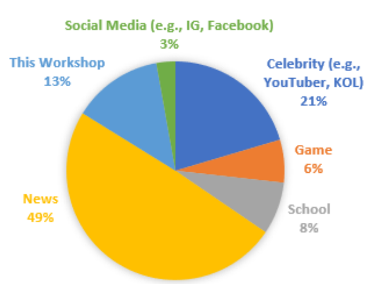

Figure 4: Pie chart of questionnaire Q5 results.

The responses from questionnaires Q5 and Q6 serve as evidence that secondary students possess a degree of awareness and understanding pertaining to blockchain, metaverse, and Web3 before the workshop. The findings from Q5 (Figure 4) show that only 13% (19 participants) were unaware of the term NFT before the workshop. Besides, the results of Q6 (Figure 5) show that some secondary students have learnt the topics of blockchain, metaverse, NFT and Web3. Even though the details of their understanding of the topics are uncertain in our study, it is realized that 28.2%-47.9% of the students had the opportunity to be introduced these terms in their secondary education. A point worth mentioning is that this workshop is specifically designed as a training section for secondary students who participated in the metaverse competition organized by a university. In other words, the participating students should be interested in metaverse and possess some basic knowledge about it.

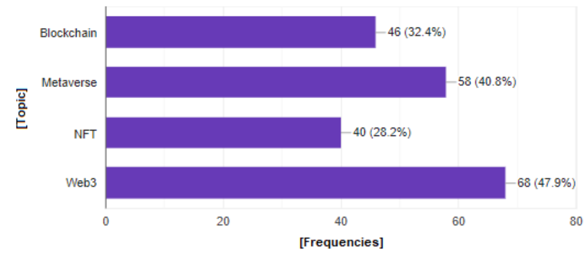

Figure 5: Bar chart of questionnaire Q6 results.

6.3 Effectiveness

Table 5: Frequency distribution and comparative result of pre- and post-quizzes.

Code	Answer	Frequency *Pre*	*Post*	*Discrepancy (Post - Pre)*
QZ1	Correct	28	29	+1
	Not Sure	4	1	-3
QZ2	Correct	21	26	+5
	Not Sure	9	2	-7
QZ3	Correct	20	22	+2
	Not Sure	10	5	-5
QZ4	Correct	9	15	+6
	Not Sure	12	4	-8
QZ5	Correct	16	24	+8
	Not Sure	9	2	-7
QZ6	Correct	18	27	+9
	Not Sure	16	4	-12
QZ7	Correct	13	18	+5
	Not Sure	7	1	-6

The column "Code" refers to the "Code" in Appendix B.

The results of the pre- and post-quizzes generated from 34 paired samples, are presented in Table 5. Results revealed that students exhibited a higher level of accuracy in their comprehension of blockchain and NFT, and noticed a decrease in uncertainty. It indicated that the workshop effectively enhance their knowledge and awareness of the concepts.

The results of Q7 to Q21 from pre- and post-questionnaires were derived from 34 paired samples and presented in Table 6, while the effect size was calculated by paired-samples t-test results.

The t-test significant value of Q7 to Q11, excluding Q10, exceeds 0.05 and is classified as insignificant, whereas the t-test significant

Table 6: Paired t-test result for questionnaire Q7 to Q21.

Code	t	Sig. (2-tailed)	Cohen's D (Effect Size)
Q7	1.436	0.160	0.246 (Small)
Q8	0.620	0.540	0.106 (Ignored)
Q9	1.537	0.134	0.264 (Small)
Q10	2.340	0.025	0.401 (Small)
Q11	0.329	0.744	0.056 (Ignored)
Q12	6.111	0.000	1.048 (Large)
Q13	4.326	0.000	0.742 (Medium)
Q14	3.368	0.002	0.578 (Medium)
Q15	5.674	0.000	0.973 (Large)
Q16	7.906	0.000	1.356 (Very Large)
Q17	5.338	0.000	0.915 (Large)
Q18	8.182	0.000	1.403 (Very Large)
Q19	10.855	0.000	1.862 (Very Large)
Q20	11.282	0.000	1.935 (Very Large)
Q21	11.566	0.000	1.984 (Very Large)

value of Q10 is classified as significant. It indicated that the workshop has a positive impact on students' interest in NFT with a minor effect, which is classified as SI instead of PI. However, the effect sizes of Q7 to Q11 are classified as small or ignored, indicating that the results of these questions are not particularly meaningful.

Particularly in the context of blockchain, cryptocurrencies, NFT, Web3, and smart contract, it has a significant impact, as the t-test significance values for these questions are less than 0.001 and classified as highly significant. In addition, the t-test significance value of Q14 is 0.002, which is deemed significant, indicating that the workshop possesses to substantially improve students' understanding of the metaverse. The effect size of Q12 to Q17 is classified as medium or greater, and the context of smart contracts is classified as very large, indicating that the results are meaningful.

The workshop significantly enhances participants' skills in utilizing crypto wallets, implementing smart contracts on the blockchain, and managing NFT, including minting, creating, and trading. This is evidenced by the t-test significant values observed among questions Q18 and Q21. The values exhibit below 0.001, indicating high statistical significance. Furthermore, all effect sizes are categorized as being of substantial magnitude.

Table 7: Topics modeling result for questionnaire Q22.

Topic	Frequency
NFT	32 (82.1%)
Skill	26 (66.7%)
Knowledge	13 (33.3%)
Blockchain	11 (28.2%)
Cryptocurrency	10 (25.6%)
Crypto wallet	5 (12.8%)
Metaverse	3 (7.7%)
Smart Contract	3 (7.7%)

39 valid responses were obtained from questionnaire Q22. The responses were analyzed using topic modeling for classification purposes, which subsequently resulted in a frequency distribution table (Table 7). The findings indicate that more than half of the student participants agree that the workshop significantly improve their practical skills. A secondary benefit identified was an enhanced comprehension of the subject's matter. The skills and concepts acquired are primarily associated with NFT, followed by blockchain, and then cryptocurrencies, while a few numbers of students mentioned crypto wallet, metaverse and smart contract.

Table 8: Statistics of assignment scores.

Code	Full Marks	Mean	SD	No. of Students Got Zero Marks	No. of Students Got Full Marks
AQ1	10	9.419	2.186	6 (4.4%)	126 (92.0%)
AQ2	10	7.720	3.357	13 (9.5%)	86 (62.8%)
AQ3	10	6.235	3.678	24 (17.5%)	57 (41.6%)
AQ4	10	4.177	2.944	36 (26.3%)	14 (10.2%)
AQ5	10	3.243	3.852	72 (52.6%)	24 (17.5%)
AE1	20	6.596	5.973	55 (40.1%)	7 (5.1%)
AE2	30	11.478	13.645	72 (52.6%)	43 (31.4%)
Total	100	48.868	22.959	0 (0%)	1 (0.7%)

136 students eventually submitted their assignment document, and Table 8 summarizes their results in each question and the total score. The result indicates that students' performance has a large deviation, both in the review questions and the workshop exercises (Appendix C). However, it is not surprising since the students have diversified academic backgrounds and not all the students are familiar with the field of information technology nor studying ICT. Still, Some have a good performance on individual questions, while there is one student who could get full scores on the whole assignment. The performance variance among the questions reflects the difficulty level of each question, and it also serves the purpose of distinguishing good performers and low achievers in the competition as a whole.

Overall, Both the results from academic performance (i.e., quiz and assignment) and students' perspectives (i.e., questionnaire) demonstrate that using situated and experiential learning in the T&L process in blockchain education for secondary students can achieve the intended learning outcomes.

6.4 Feedback

Table 9: Frequency distribution for questionnaire Q23 to Q27.

Code	Strongly Dissatisfied	Dissatisfied	Neutral	Satisfied	Strongly Satisfied
Q23	0 (0%)	0 (0%)	2 (5.9%)	25 (73.5%)	7 (20.6%)
Q24	0 (0%)	0 (0%)	4 (11.8%)	24 (70.6%)	6 (17.6%)
Q25	0 (0%)	0 (0%)	2 (5.9%)	23 (67.6%)	9 (26.5%)
Q26	0 (0%)	0 (0%)	2 (5.9%)	23 (67.6%)	9 (26.5%)
Q27	0 (0%)	1 (2.9%)	6 (17.6%)	20 (58.9%)	7 (20.6%)

Table 9 summarizes the responses from the workshop participants for the questionnaire Q23 to Q27. The results (Q23 to Q26) show that students are satisfied with the course activities, content, knowledge enhancement, and learning experience. At least 85% of students rated satisfied or strongly satisfied with the above-mentioned four items. Except for the teaching materials (Q27), only 78% rated satisfied or strongly satisfied. Seven valid responses were received in Q28, while three of them are responses towards the teaching materials:

- *"The PowerPoint may add more flow diagrams, and not just only using text."*
- *"The script provided by the workshop should work outside of the teaching PC (it doesn't)."*

- *"Not just following the instructions to finish the workshop, but more is to explain."*

In general, some students were expecting more visualizations of the concepts in the teaching materials and more step-by-step guidelines from the instructor. Also, the hands-on materials, in the form of software tools, may not be always compatible with students' own machines. It is no surprise that these are common academic and technical difficulties encountered by students in IT education. The situation is even worse for secondary students who have less computing background than tertiary-level students, and they may not have sufficient technical skills and problem-solving techniques to resolve unexpected issues during the learning process. While the teaching team has strived to address these problems during the design and implementation of the workshop, the feedback serves as a good reference for future refinement of the T&L materials and improvement on the way of delivery.

6.5 Data Validity and Limitation

The demographic samples of Q2 to Q4 were filtered using the response of Q1 as a primary key to remove duplicate records, resulting in a total of 144 samples. In addition, this study applied a paired samples t-test instead of an independent t-test to examine the pre- and post-questionnaire responses for Q7 to Q21 and Q23 to Q27. This approach was chosen because it allows for the measurement of changes within the same group of students before and after the workshop rather than comparing distinct cohorts. Hence, 142 responses from the pre-questionnaire and 44 responses from the post-questionnaire were distilled into 34 paired samples. The responses to those questions will be considered a sample if and only if the students complete both pre- and post-questionnaires. The responses of Q5, Q6, Q22, and Q28 were served as the sample without any filtering, as these questions were not paired.

Besides, the submitted assignments in this workshop were graded by the department's academic staff, who have extensive experience in teaching computing-related subjects. The grading is based on a holistic marking rubric.

Additionally, the double data entry method is performed to validate the statistical results, ensuring the reliability of the findings. This method is used throughout the process, from constructing a dataset to generating results.

However, the small size of the paired samples is the limitation of this study, which potentially restricts the generalizability of our findings. Consequently, it is advisable to be careful when generalizing about larger populations. Another possible limitation is the region, as this workshop is tailored to secondary students in Hong Kong. There may be differences in the outcomes when it is deployed for secondary students in various regions. Deployers are recommended to consider the regional or national curricular structure to adapt the contents accordingly.

7 DISCUSSION

The findings of this study indicate that the workshop offers the capacity to effectively improve knowledge and skill in blockchain, as well as eventually convert to awareness among secondary-level students, as evidenced by the results of questionnaire Q12-Q21, quiz, and assignment. This can be accomplished by applying the principles of transfer of learning which transform their comprehension from metaverse (the entry point) to blockchain via NFT as the bridging component (RQ1).

However, the transfer of the students' PI from the metaverse to the blockchain's SI (RQ2) appears to have very little or no impact in this study, as indicated by the significant values and effect sizes obtained from questions Q7 to Q11. The inconsistent results cannot provide conclusive proof to fully substantiate the workshop's capacity to cultivate students' interest in blockchain. However, it is evident that the workshop successfully cultivated an interest in blockchain among certain students. Perhaps the topic of blockchain remains inconsequential to certain students, as the attendees of this workshop concentrate mainly on participating in the metaverse competition rather than acquiring knowledge about blockchain.

It can be realized that transfer of learning can be effectively applied to learning blockchain in a metaverse context. In a similar fashion, if blockchain is selected as an entry point, could it serve as a bridge to help the introduction of Web3 and metaverse? It remains an open question for further research on the possibility and its effectiveness. One possibility is to use smart contract as the bridging medium. For example, in a smart contract programming course, the relevant concepts of metaverse and Web3 can be introduced by highlighting how metaverse and Web3 systems adopt blockchain technologies and why metaverse and Web3 play a crucial role in sustaining the development of blockchain technologies.

8 CONCLUSION

A T&L approach for secondary students to acquire the concepts of blockchain is proposed in this paper, in which it adopts four educational theories, including Transfer of Learning, Interest Theory, Situated Learning, and Experiential Learning. A three hours workshop that consists of an introduction mini-lecture of fundamental concepts of blockchain and a hands-on laboratory session was designed and implemented.

Due to the technical relationship among blockchain, metaverse, and Web3, the possibility of transfer of learning from metaverse to blockchain is investigated. The workshop adopted NFT as the bridging medium to help students understand the concepts of blockchain, by introducing the application of NFT in metaverse as a concrete example. Awareness of blockchain is consolidated through a set of hands-on NFT minting and trading tasks.

Our research findings suggest that the workshop can achieve the intended learning outcomes in terms of knowledge, skill, and particularly awareness development. While it can be seen from our design and implementation that learning blockchain from the metaverse context is effective, it remains an open question if the audience has a fundamental background/interest in blockchain technology, transfer of learning would still be effective in the introduction of metaverse and Web3 to the audience.

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A PRE- AND POST-QUESTIONNAIRE QUESTIONS

Code	Type	Question
Q1	Short Answer	Please write down your e-mail address.
Q2	Closed-ended	What is your gender?
Q3	Closed-ended	What is your current studying year?
Q4	Multiple Choice	What is/are your elective subject(s)?
Q5	Multiple Choice	The first time that I hear the term "NFT" is from…
Q6	Multiple Choice	When I was in secondary school, I learned… (Blockchain/Metaverse/NFT/Web3)
Q7	5-point Likert	I am interested in Blockchain.
Q8	5-point Likert	I am interested in Cryptocurrency.
Q9	5-point Likert	I am interested in Metaverse.
Q10	5-point Likert	I am interested in NFT.
Q11	5-point Likert	I am interested in Web3.
Q12	5-point Likert	I understand what Blockchain is.
Q13	5-point Likert	I understand what Cryptocurrency is.
Q14	5-point Likert	I understand what Metaverse is.
Q15	5-point Likert	I understand what NFT is.
Q16	5-point Likert	I understand what Smart Contract is.
Q17	5-point Likert	I understand what Web3 is.
Q18	5-point Likert	I know how to use crypto wallet.
Q19	5-point Likert	I know how to mint/create an NFT.
Q20	5-point Likert	I know how to deploy a smart contract on blockchain.
Q21	5-point Likert	I know how to trade an NFT.
Q22	Open-ended	What did you learn from this workshop?
Q23	5-point Likert	Please rate the course activities of the NFT workshop.
Q24	5-point Likert	Please rate the course content of the NFT workshop.
Q25	5-point Likert	Please rate the knowledge enhancement of the NFT workshop.
Q26	5-point Likert	Please rate the learning experience of the NFT workshop.
Q27	5-point Likert	Please rate the teaching materials of the NFT workshop.
Q28	Open-ended	Do you have other comments on this NFT workshop?

Q5 and Q6 are asked in pre-questionnaire only, while Q22 and Q28 are asked in post-questionnaire only.

B PRE- AND POST-QUIZ QUESTIONS

Code	Question
QZ1	All NFT are completely unique.
QZ2	Ethereum is the only blockchain that supports NFT.
QZ3	NFT and Cryptocurrency are the same.
QZ4	NFT can be deleted.
QZ5	NFT metadata is not allowed to change.
QZ6	Smart contract can be used to distinguish the uniqueness of NFT.
QZ7	The ownership of NFT is immutable.

C ASSIGNMENT TASKS

Code	Type	Content	Proportion
AQ1	Review Question	Name two cryptocurrencies with the highest market cap in the world.	10%
AQ2	Review Question	What is the difference between Blockchain 1.0 and Blockchain 2.0?	10%
AQ3	Review Question	In the workshop, what is the cryptocurrency used for paying transaction fees in Ethereum	10%
AQ4	Review Question	In ONE sentence, describe the purposes of the smart contract in our lab.	10%
AQ5	Review Question	Use the Goerli Testnet Explorer to search for a transaction by specific transaction hash. Briefly describe the purpose of the transaction.	10%
AE1	Workshop Exercise	Send your NFT to your teammate in MetaMask and document the process by providing screenshots and include it in the assignment document. Also, answer why need to pay transaction fees.	20% (6% for describing steps of transferring NFT + 6% for discussing paying fee's reason + 8% for capturing screen)
AE2	Workshop Exercise	Create and mint a 3D NFT object and place it on Opensea for trading.	30%