Online-Journals.org

iJEP International Journal of Engineering Pedagogy

iJEP | eISSN: 2192-4880 | Vol. 15 No. 1 (2025) | OPEN ACCESS

https://doi.org/10.3991/ijep.v15i1.51461

PAPER

The Outcomes of Project-Based Learning System on Metaverse through Design Thinking for Buddhism Innovators

Kiattisak Sisamud[1](✉), **Pinanta Chatwattana**[2], **Pallop Piriyasurawong**[2]

[1]Office of the General Buddhist Education 13, Bangkok, Thailand

[2]King Mongkut's University of Technology North Bangkok, Bangkok, Thailand

jerambo2@gmail.com

ABSTRACT

The project-based learning system on the metaverse through design thinking for Buddhism innovators, or the PjBL system on the metaverse, is designated to be used as a tool to promote self-directed learning and Buddhism in Thailand. The PjBL system on the metaverse emphasizes the learning style that can develop the 21st-century skills, and the system relies mainly on the processes of project-based learning and design thinking, which are believed to bring about creative strategies for the development of new innovations based on new ideas. The PjBL system on the metaverse can be put into practical use in digital learning environments on the metaverse, which are capable of providing realistic and immersive learning experiences in such a way that users can feel as if they were in the physical world. The system also supports interactions, easy access to learning resources, and sharing of information, all of which are said to increase learners' confidence and practical skills in using digital technologies. This study was carried out by means of pre-experimental research method with a one-group pre- and post-test design, and the research results are consistent with all four research hypotheses. According to the observations, it is found that the PjBL system on the metaverse is considered a learning tool in the virtual world that Buddhist innovators can practically apply to create new innovations to promote Buddhism through immersive learning technology. Furthermore, the PjBL system in the metaverse can promote experiential learning, enabling users to acquire new bodies of knowledge as to their own abilities, find out new methods to solve problems, create their own works, carry out their tasks efficiently, develop different knowledge and experiences, and improve necessary technological skills needed in today's era.

KEYWORDS

PjBL system on metaverse, design thinking, Buddhism innovators

Sisamud, K., Chatwattana, P., Piriyasurawong, P. (2025). The Outcomes of Project-Based Learning System on Metaverse through Design Thinking for Buddhism Innovators. *International Journal of Engineering Pedagogy (iJEP)*, 15(1), pp. 56–74. https://doi.org/10.3991/ijep.v15i1.51461

Article submitted 2024-07-30. Revision uploaded 2024-11-15. Final acceptance 2024-11-15.

1 INTRODUCTION

Since scientific and technological innovations have become significant mechanisms for economic and social development, innovators are playing a more and more important role in the creation of new innovations for use in national development. The outbreak of COVID-19 over the past few years has brought about some major changes in learning methods, which must be adapted to align with the unexpected situations. As a result, most of the traditional learning methods have shifted to digital online learning [1] [2]. Not only that, the propagation of Buddhism in Thailand, the land of cultural diversity, has also been affected by this situation, and there should be major adaptation in the dissemination of Buddhism. Buddhist Innovations (BI), therefore, are highly needed in the current situation in order to facilitate Buddhists of all ages to gain bodies of knowledge and concrete understandings of Buddhist principles and, meanwhile, apply them in an appropriate and practical manner [3].

Sitthithammaporn et al. [4] said that Buddhism is recognized as a crucial cultural foundation of Thai society, and the principles of Buddhist teachings have been propagated in Thai society for a long time. Once stepping into the 21st century, when the world has no borders, both global societies and Thai society began to face more crises in many aspects. Consequently, the learning methods about Buddhism and the dissemination of Buddhist principles require some adjustments so that they can be consistent with the changing contexts in the 21st century. There are two main issues that need the said adjustment. The first one is the teaching skills required in the propagation of Buddhism. These skills should be developed in such a way that the Buddhist teachings must be easy to understand, easy to remember, and can be put to practical use. The other is the adjustment in the use of information technology in the study of Buddhism and the dissemination of Buddhist teachings to consumer groups. Thus, it is necessary for both the government and the Buddhist church to work hand in hand so as to deal with the problems and support the dissemination of Buddhist principles, making them easy to understand and applicable to people's lives. It is expected that the use of new technologies to propagate Buddhism can enhance the Buddhists' quality of life, and at the same time cope with some social crises in a sustainable manner.

The National Education Act B.E. 2562 (No. 4) places an emphasis on education management that can promote students' full potential in a natural manner. In reference to Section 22 of the said act, education must equip students with knowledge and skills related to science and technologies, including understanding and experiences in management, maintenance, and utilization of natural resources and the environment in a sustainable manner. In the meantime, the instruction management must comprise various activities for students to practice and learn from first-hand experiences so that they are able to think and do their tasks efficiently, which will eventually arouse their constant curiosity. Not only that, the ideal instruction management must promote and assist instructors to create appropriate atmospheres, environments, learning media, and hands-on practices that can encourage students to learn, develop their omniscience by means of practical practice, and improve the 21st-century skills [5] that are necessary for self-adjustment and self-development. This is all for the students to apply such skills relevant to thinking, collaboration, communication, and creativity [6] in their daily lives.

Referring to the above context, there have been technological and social changes in the 21st century, all of which focus on the improvement of the quality of social services, especially those related to education, exchange of knowledge, and

interaction through the network system. As a result, more and more Thai people are able to have unlimited access to information [7]. All of the aforementioned are in line with the main goals of Thailand's educational development as stated in the National Scheme of Education B.E. 2560–2574, that is, the education system must be of high quality and efficiency so that it can serve as the main mechanism to develop human potentialities and competencies. In the meantime, it must be able to accommodate both education and learning and correspond with the challenges of the world's dynamics [8].

This study is related to the exploration of the participants' perspectives towards the development of the project-based learning system on the metaverse through design thinking for Buddhism innovators, or the PjBL system on the metaverse. The study is also intended to verify that the self-directed learning based on design thinking with the PjBL system on the metaverse can generate and support learning organizations because the system can encourage the application of digital technologies in instruction management that corresponds to lifelong learning and, meanwhile, can enhance Buddhist innovators skills necessary for the creation of innovations for the effective propagation of Buddhism in Thailand. Thus, the main objectives of the present study are to develop the project-based learning system on the metaverse through design thinking for Buddhism innovators and to examine the perspectives of the research participants towards the development of this system after they have conducted self-learning with digital technology, in which they are able to interact with virtual environments therein.

The research hypotheses are based on the study of the results after using the PjBL system on the metaverse. Thereby, the hypotheses of this study include:

- H_1: The efficiency of the project-based learning system on the metaverse through design thinking for Buddhism innovators, or the PjBL system on the metaverse, is at high level.
- H_2: The scores of learning achievement after learning with the PjBL system on the metaverse are higher with statistical significance at .01.
- H_3: The Buddhism innovator scores of the learners who have learned with the project-based learning system on the metaverse through design thinking for Buddhism innovators are at high level.
- H_4: The satisfaction of the learners who have learned with the project-based learning system on the metaverse through design thinking for Buddhism innovators is at high level.

2 BACKGROUND

People all over the world have always been facing many challenges,such as wars, natural disasters, epidemics, and many other bad events. However, the outbreak of COVID-19 around the world resulted in an urgent need for online teaching and learning at all levels. In 2020, the traditional face-to-face learning style could not be conducted owing to the spread of COVID-19 [9]. As a result, the new paradigms took place, and since then the new technologies have been employed to create opportunities related to the creation of knowledge, interaction among learners, and exchange of knowledge and collaboration. All of these have contributed to the rise of the quality of social services, especially those concerning education, through the network system [10] in order to provide education management that can promote students to

develop various skills and create new bodies of knowledge. The following theories were analyzed so as to identify the concepts related to this study:

- Project-based learning
- The metaverse
- Design thinking
- Buddhist innovators skills

2.1 Project-based learning

Project-based learning is a kind of learning process that helps students possess the 21st-century skills. Each of the steps within this instruction management is intended to promote the student-centered learning and increase the efficiency of the classroom learning. Students are expected to develop problem-solving skills, critical thinking skill, and ability to create their own works. This can promote creativity, teamwork, and collaborative learning skill as well. Moreover, the project-based learning can also promote communication and interaction among learners particularly when using the current technological tools in such digital age, which is considered an appropriate combination for the present time. For this reason, the project-based learning is regarded as one of the approaches that should be integrated into the instruction management so as to provide learners with indispensable skills for the 21st century [11]. There are six steps in the project-based learning management as follows:

- Step 1 Preparation: Instructors prepare the project scope as well as the information sources and identify the leading questions in the learning plan.
- Step 2 Topic Definition and Selection: Each group of learners proposes the project topics, study the possibilities of the proposed topics, and then present the said topics to the instructors for further approval.
- Step 3 Project Layout: Learners study the project scope and find out the related information sources. Then learners set up the project implementation plan by identifying the activities designated for each step in the plan, the roles and responsibilities along with the workload of each member, and the time needed for the project implementation.
- Step 4 Project Implementation: All group members use their knowledge and skills to do their tasks as given in the plan; and meanwhile exchange their experiences with others in order to explore new bodies of knowledge. At the meantime, instructors are available for assistance and advice or helping learners deal with the problems found during this process.
- Step 5 Presentation: Learners summarize their project results in the form of report and present it to others so that they can exchange their knowledge with other groups.
- Step 6 Evaluation: Instructors employ different methods and tools to do authentic assessment on the results of the project.

2.2 Metaverse

Metaverse is a virtual reality platform that allows users to create virtual environments and interact with them via virtual digital platforms. Thereby, the said digital

platforms contain multi-user environments which are the integration of physical reality and virtual world [12]. Therefore, metaverse is deemed as a network of virtual worlds in which users can not merely receive varied immersive experiences but also share them through their avatars [13]. Park and Kim [14] explained the four main components of metaverse as below:

- Environment: This element includes the recognition of scenes and objects, the recognition of sound and speech, the generation of scenes and objects, the synthesis of sound and speech, motion rendering, etc.
- Interface: This element consists of head-mounted displays, hand-based and non-hand-based input devices, motion input devices, etc.
- Interaction: This element refers to varied formats of continuous interactions, multitasking interactions, person modeling, creation of simulations, etc.
- Security Privacy: This element includes data security and privacy, security of software, hardware, and network aspect, etc.

After inspecting the concepts, the theories, and the literatures concerning the metaverse [15], it is found that the metaverse can be integrated into education to facilitate instruction and learning processes in order to increase accessibility and equality in education. This is because the metaverse provides learners with more opportunities to access and make use of virtual learning resources. In addition, in the instruction process using new technologies, learners can interact with others in order to learn and create interactive content. This is believed to enhance the quality of teaching, provide more opportunities to access education, and prepare proficient individuals for the upcoming digital and dynamic world.

2.3 Design thinking

Design thinking refers to the thinking process that is aimed at finding out creative strategies for developing desirable works. It is also the thinking method that has been widely used to develop innovations by many technical officers in various fields. In addition, design thinking has been developed to promote cognitive learning and computer design [16] with an intention to fabricate innovations that can solve problems, create works, assist in working efficiently, and develop diverse bodies of knowledge and experiences, as well as technological skills needed in the present time [17]. Furthermore, the design thinking process also leads to new forms of creative thinking that can be employed to analyze and solve problems, discover new solutions to problems, and create new innovations.

Therefore, the instruction management using the design thinking process is considered a fundamental design method that can pave ways for other problem-solving approaches; so it is very useful when dealing with complex problems. For instance, the said problem-solving approach may focus on understanding human needs, framing the problems based mainly on humans, brainstorming for different ideas, creating a prototype, and testing the said prototype. Thereby, the design thinking process consists of five steps, i.e., empathize, define, ideate, prototype, and test [13]. Besides, Brown [18] divided the design thinking process into three phases, i.e., inspiration, ideation, and implementation, insisting that this process will lead to understanding of problems and solutions and then the creation of new ideas for the new inventions.

The aforementioned contents illustrate the concepts and the principles of learning management using the design thinking process, which is intended to create

new and diverse innovations. Additionally, the design thinking process also has a flexible format and a learning management format that can be well adapted to different contexts. Therefore, the design thinking process has been employed to promote creativity, the value of teamwork, and problem-solving skills, which are said to create the competencies of innovators to create innovations in various contexts; for example, the competencies of Buddhist innovators, which are the abilities to create innovations for use in the dissemination of Buddhism.

2.4 Buddhist innovators skills

Buddhist innovators skills refer to the skills related to the creation of innovations designated specifically for Buddhist innovators to promote Buddhism [3]. Whereby, Buddhist innovators are those who use their knowledge, creativity, and skills in information technology to create Buddhist innovations as well as creative innovative media, which will be used to propagate Buddhism for Buddhist people [4].

In this study, the researchers had synthesized Buddhist innovators skills [19]–[22] from the relevant documents and researches, and then acquired the five major characteristics, i.e., 1) observation, 2) questioning, 3) networking, 4) experiment, and 5) linkage, for use as the concepts of Buddhism. The synthesis on these five main characteristics results in the following four aspects of Buddhist innovators skills.

Observation and questioning: This aspect is the ability to ask questions and observe the problems or details regarding the trends of innovations used to promote Buddhism.

Creation of Buddhist network: This refers to the ability to express opinions and discuss innovative ideas about the propagation of Buddhism.

Creative innovation: It is the ability to create the unprecedented models of innovations from the brand-new ideas in order to promote Buddhism in an appropriate and constructive manner.

Cognitive linkage: This aspect is the ability to seek new information and different ideas pertaining to the creation of innovations to promote Buddhism.

3 RESEARCH METHODOLOGY

3.1 Research design

The methodology of this study relies mainly on the pre-experimental research method with one group pre- and post-test design. The researchers decided to use this method because the researchers wanted to prove the capability and efficiency of the developed system by comparing the learners' knowledge before and after learning with this system. Moreover, the researchers also wanted to see whether the learners have higher learning achievement or not after using the said system. Above all, the size of the sample group is quite small ($n < 30$) since the study requires only the participants with unique characteristics, that is, the novice students of the Chinese Mahayana sect. Regarding all of the above reasons, the researchers selected the pre-experimental research method with one a group pre- and post-test design in this study.

3.2 Participants

The research participants include (1) five experts, derived by means of purposive sampling, from various higher education institutions, all of whom are specialized in the design and development of instruction systems. In this study, the researchers recruited these experts based on the criterion that each of them must have at least seven years of experience in education and in the design and development of instruction systems. However, all the experts were requested to voluntarily participate in this study. The other participants are 27 novice students at the high school level of the Chinese Mahayana sect from Mangkorn Kamalawat Wittayalai School, Office of the General Buddhist Education 13, all of whom were selected by means of cluster sampling. The research participants of both groups were well protected with the policies of confidentiality and anonymity according to the research ethics to which the researchers always strictly adhere. However, the researchers did not apply for approval from the research ethics committee because this study is considered just low-risk research, and it is intended to test general behaviors of the volunteers in a short period of time. Besides, the research is risk-free, and it did not collect any data that could identify the volunteers in this study.

3.3 Instruments and data analysis

The instruments used for data collection in this research consist of (1) The project-based learning system on the metaverse through design thinking, or the PjBL system on the metaverse. (2) The 5-rating scale evaluation form on the quality of the PjBL system in the metaverse, which is based on the Likert Scale [23] and composed of 20 questions designated to assess four aspects, i.e., (1) consistency to user's needs, (2) functionality, (3) ease of use, and (4) efficiency. In other words, this form is aimed at examining the capability of the PjBL system in the metaverse. (3) The multiple-choice evaluation form (four choices) on the learning achievement before and after learning with the system. (4) The 4-rating scale measurement form for authentic assessment of the Buddhism innovator characteristics. The researchers had synthesized the questions and the criteria in this evaluation form from the research related to Buddhist innovators [19]–[22]. (5) The 5-rating scale evaluation form on the satisfaction towards the PjBL system on the metaverse contains 20 questions asking about the elements of the PjBL system on the metaverse, e.g., contents, suitability of design, instruction activities, efficiency of the system, etc.

The criteria and the interpretations [23] of this 5-rating scale evaluation form are as follows:

- Average score of 4.50–5.00 refers to very high level
- Average score of 3.50–4.49 refers to high level
- Average score of 2.50–3.49 refers to average level
- Average score of 1.50–2.49 refers to low level
- Average score of 0.00–1.49 refers to very low level

The statistics used for data analysis [23] are mean, standard deviation, and t-test dependent. The researchers employed a dependent t-test because the test of hypotheses in this study was conducted by comparing the means between the two related sample groups of fewer than 30 people. Thereby, the differences of pre- and post-test scores of a single sample group were tested.

3.4 Data collection

The researchers had the evaluation forms and the measurement form on the learning achievement proved for index of item objective congruence (IOC) by experts in order to make sure that the questions in these forms are in consistency with the PjBL system on the metaverse through design thinking in this study. Prior to the voluntary assessment on this form, all participants had been clearly informed that they could feel free to make decisions to participate in the study, and they all were assured that their identity shall not be disclosed.

3.5 Method

In reference to the research methodology, the researchers based the design and the development of the PjBL system on the metaverse on the systems approach [24] [25] combined with the concepts and the theories of the system development life cycle (SDLC), which indicates the steps and processes of the system development [26]. Whereby, the research methodology can be summarized into three phases as below:

Phase 1: Study, analyze, and synthesize the documents and the researches related to the project-based learning and design thinking process in order to establish the project-based learning process on the metaverse through design thinking for Buddhism innovators.

Phase 2: Develop the PjBL system on the metaverse through design thinking for Buddhism innovators. In this part, the researchers developed the system by integrating the principles of systems approach with the concepts and the theories of SDLC, which represents the steps and processes of the system development. The PjBL system on the metaverse was also developed on Spatial.io platform because it is compatible with a variety of interactive displays (Responsive Web Design).

Phase 3: Study the results after using the PjBL system on the metaverse through design thinking for Buddhism innovators. The participants gave their consent to join this research and answer the questions in all evaluation forms. They were well protected under the policies of confidentiality and anonymity.

4 RESULTS

The results of the design and development of the project-based learning system on the metaverse through design thinking for Buddhism innovators, can be concluded as below:

4.1 Results of phase 1: Synthesis of the project-based learning process on the metaverse through design thinking for Buddhism innovators

According to the study, analysis, and synthesis of the documents and the research related to the project-based learning and the design thinking process with an intention to set up the project-based learning process on the metaverse through design thinking for Buddhism innovators in Thailand, the results thereof can be concluded as presented in Tables 1 and 2.

Table 1. Synthesis of project-based learning management

Learning Process	[11]	[27]	[28]	[29]	[30]	[31]	[32]	[33]	This Work
Preparation	✓		✓			✓	✓		✓
Topic definition	✓		✓	✓		✓	✓		✓
Research						✓	✓		
Creation of project outline		✓	✓			✓	✓	✓	
Development and test	✓	✓	✓				✓	✓	✓
Report		✓	✓			✓			
Project presentation	✓	✓	✓		✓	✓		✓	✓
Evaluation	✓	✓		✓	✓		✓		✓

Table 1 represents the process of project-based learning management, which was synthesized based on the relevant documents and research [11], [27]–[33]. The process derived from the said synthesis can be divided into the following five steps. The first step is "preparation," in which the instructor prepares the learning management plan as to the course objectives and then organizes an orientation for the students to understand the project-based learning. In the meantime, the instructor gives advice and suggestions and allows the students to form their groups, search for information, do brainstorming, study possibilities, summarize problems, and prepare the project plans. Secondly, it is the step of "topic definition," in which the instructor approves the students' projects, gives feedback, and monitors the process of project-based learning. After that, the students create their project plans and present their project topics and then receive suggestions and make improvements. The third step is "development and test." In this step, the instructor monitors and examines the students' operations and meanwhile, listens to their problems and suggestions. Then, the students are allowed to create and test their works. In case of any problems, the students shall troubleshoot the said problems. Next, it is the step of "project presentation." The instructor listens to the students' presentations and makes suggestions along with the moral support for their projects. The students, after presenting their works, receive and apply the helpful suggestions to improve their works. Finally, it is the "evaluation" step, in which the instructor and the experts conduct the authentic assessment on the projects. At the same time, the students are also allowed to evaluate both their own works and their classmates.'

Table 2. Synthesis of learning management through design thinking process

Learning Process	[34]	[35]	[36]	[37]	[38]	[39]	This Work
Empathize	✓	✓	✓	✓	✓	✓	✓
Define	✓	✓	✓	✓	✓	✓	✓
Ideate	✓	✓	✓	✓	✓	✓	✓
Prototype	✓		✓	✓	✓	✓	✓
Test	✓		✓	✓	✓	✓	✓

According to the synthesis of the design thinking process in Table 2, the researchers had synthesized the relevant documents and research [34]–[39] and found out the five steps of the design thinking process for use in this study. Firstly, it is the step of

"empathize," which refers to the search of all problems that arise both directly and indirectly to users. The second step is "define," which means the problems found in the step "empathize" are used to define the more specific problem as well as its sequences. The next step is "ideate," in which the developers are allowed to propose their ideas, which may seem either possible or impossible, so as to find out new approaches to solve that problem. The fourth step is "prototype." This refers to the creation of a temporary prototype method based on the ideas acquired in the step "ideate" in order to study the results of the preliminary testing. The final step is "test," in which the results of the prototype method are finally tested and the feedback thereof is collected.

4.2 Results of phase 2: Development of the project-based learning system on the metaverse through design thinking for Buddhism innovators

The PjBL system in the metaverse is intended to be employed as a tool to encourage self-directed learning and, meanwhile, promote Buddhism in Thailand. In the design and development of the PjBL system in the metaverse, the researchers rely mainly on the concepts of project-based learning management combined with the design thinking process in order to acquire the learning process that can support the creation of innovations suitable for the propagation of Buddhism in Thailand. The overview is shown in Figure 1.

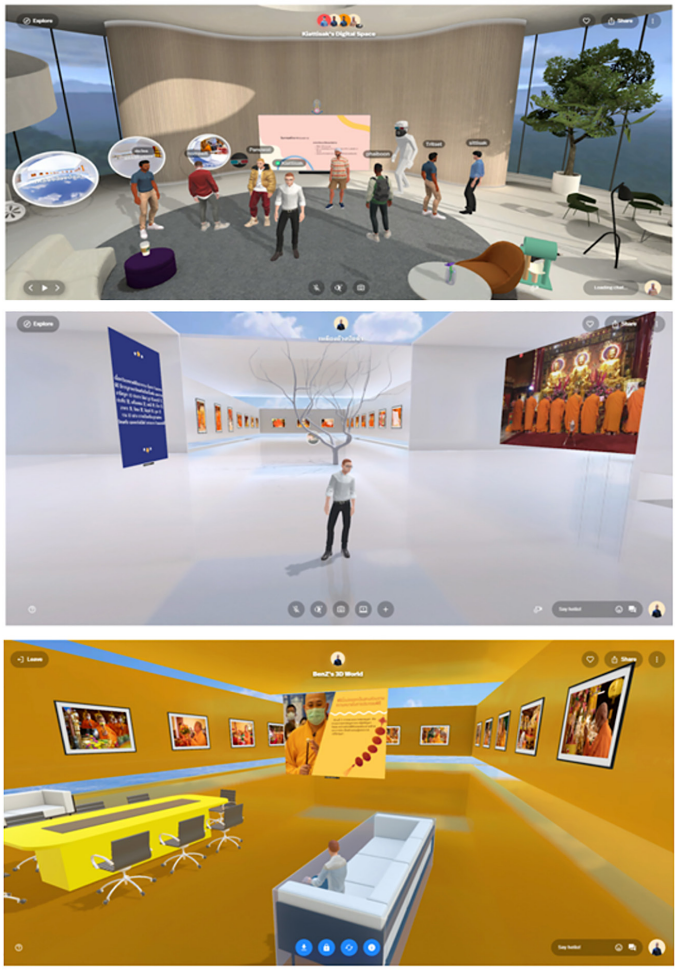

Fig. 1. The PjBL system on the metaverse for Buddhism innovators in Thailand

The PjBL system on the metaverse in this study features an interactive screen design that is consistent with the needs of smartphone users. The system was developed on the Spatial.io platform, and it is compatible with a variety of interactive displays (Responsive Web Design). In addition, the researchers also applied the technologies about learning in the metaverse in this system in order to provide learners with new experiences and immersive self-learning as if they were in the physical world.

Table 3. The quality of the PjBL system on the metaverse for Buddhism innovators

Evaluation List	Mean	SD	Level
Consistence to user's needs			
1. Ability to run the metaverse	4.80	0.45	Very high
2. Ability to add information through the metaverse	4.80	0.45	Very high
3. Ability to update information through the metaverse	5.00	0.00	Very high
4. Ability to present information through the metaverse	5.00	0.00	Very high
5. Validity and completion of database system	4.80	0.45	Very high
Total of consistence to user's needs	4.88	0.27	Very high
Functionality			
1. Accuracy of system functionality	4.80	0.45	Very high
2. Accuracy in classification of information	4.80	0.45	Very high
3. Accuracy in addition of information	5.00	0.00	Very high
4. Accuracy in update of information	5.00	0.00	Very high
5. Accuracy in presentation of information	5.00	0.00	Very high
Total of functionality	4.92	0.18	Very high
Ease of use			
1. Ease of running the system	4.80	0.45	Very high
2. Suitability of the metaverse design	4.60	0.55	Very high
3. Clarity of information displayed in the metaverse	5.00	0.00	Very high
4. Convenience of access to the metaverse	4.60	0.55	Very high
5. Attractiveness of the system	4.80	0.40	Very high
Total of ease of use	4.76	0.40	Very high
Efficiency			
1. Speed of data display	4.80	0.45	Very high
2. Speed of communication with database	4.60	0.55	Very high
3. Speed of saving and updating information	5.00	0.00	Very high
4. Speed of presentation of information	4.80	0.45	Very high
5. Overall speed of system operation	4.80	0.45	Very high
Total of efficiency	4.80	0.38	Very high

In reference to the results of evaluation on the quality of the PjBL system in the metaverse for Buddhism innovators in Thailand in Table 3, it is found that the quality of the system in all aspects, i.e., consistency to user's needs (mean = 4.88, SD = 0.27), functionality (mean = 4.92, SD = 0.18), ease of use (mean = 4.76, SD = 0.40), and efficiency (mean = 4.80, SD = 0.38), are at a very high level. This means the aforementioned results are in line with hypothesis 1.

Moreover, the results insist that the PjBL System in the metaverse for Buddhism innovators in Thailand is considered such an efficient learning tool that it can be applied in practical use to promote Buddhism in Thailand through the processes of project-based learning and design thinking. Whereby, the integration of project-based learning and design thinking processes mentioned herein can be conducted in digital learning environments via the Spatial.io platform, which can provide realistic

learning experiences and enable learners to gain immersive learning experiences as if they were in the real world. This is in line with the research of Chatwattana et al. [40], who stated that the utilization of innovations and digital technologies to the maximum benefits in instruction management, research, academic services, and lifelong learning in higher education can lead to learning organizations and lifelong learning in the future. Besides, these learning styles are the new dimension of borderless learning that can offer self-learning experiences directly because learners can communicate and interact more with one another.

4.3 Results of phase 3: Results after using the project-based learning system on the metaverse for Buddhism innovators in Thailand

After conducting the synthesis on the related documents and research [19]–[22] in order to find out the ideal characteristics of Buddhism innovators for use in this study, the researchers summarized the main Buddhism innovator characteristics into four aspects, i.e., observation and questioning, creation of a Buddhist network, creative innovation, and cognitive linkage (see Table 4).

Table 4. Synthesis of characteristics of Buddhism innovators

Buddhism Innovator Characteristics	Desirable Characteristics
Observation and questioning	Ability to ask questions and observe the problems or details regarding the trends of innovations used to promote Buddhism.
Creation of Buddhist network	Ability to express opinions and discuss innovative ideas about the propagation of Buddhism.
Creative innovation	Ability to create the unprecedented models of innovations from the brand-new ideas in order to promote Buddhism in an appropriate and constructive manner.
Cognitive linkage	Ability to seek new information and different ideas pertaining to the creation of innovations to promote Buddhism.

The results after using the PjBL system in the metaverse for Buddhism innovators in Thailand were acquired from the feedback of 27 research participants, who are novice students at the high school level of the Chinese Mahayana sect from Mangkorn Kamalawat Wittayalai School, Office of the General Buddhist Education 13. All of these participants were selected by means of cluster sampling, and they were willing to complete the questionnaire in the evaluation form. Furthermore, these participants were well protected under the policies of confidentiality and anonymity. This study is conducted based on the pre-experimental research method with one group pre-test/post-test design.

Table 5. Comparative of learning achievement (N = 27)

Learning Achievement	Full Score	Mean	SD	t-Test	Sig.
Pre-test	30	14.22	3.88	13.67	.00**
Post-test	30	19.59	4.51		

Note: **Significant at the level of 0.01 ($\alpha = 0.01$, df = 29).

According to the comparison of learning achievement before and after using the PjBL system in the metaverse in Table 5, which was carried out by means of one

group pre-test/post-test design, it is evident that the score of learning achievement after learning with the said system is noticeably higher. In other words, the mean score of learning achievement after learning with the PjBL system in the metaverse is 19.59 with the standard deviation (SD) of 4.51, whereas the mean score and the standard deviation before learning are 14.22 and 3.88, respectively. Thus, it can be clearly seen that learning with the PjBL system in the metaverse enables learners to have better learning achievement with statistical significance at .01, which is in consistency with hypothesis 2.

The study results mentioned above are in compliance with the research of Saiseenin et al. [41], who said that the application of concepts, principles, and theories of the new teaching innovations to facilitate the learning styles that can be performed anywhere and anytime can provide self-learning experiences since learners are able to interact and communicate with one another. In addition, learners can also practice on their own, which is said to result in better learning achievement as well.

The results of the evaluation of the characteristics of Buddhism innovators after using the PjBL system in the metaverse were derived by means of the 3-rating scale authentic assessment. The criteria for interpretation are as follows:

- 9.00–12.00 p. – very high level of characteristics of Buddhism innovators,
- 5.00–8.99 p. – high level of characteristics of Buddhism innovators,
- 0.00–-4.99 p. – very low level of characteristics of Buddhism innovators.

Table 6. Results of evaluation on the characteristics of Buddhism innovators

Number of Students	Full Score	Mean	Percentage	Interpretation
27	12	10.59	88.27%	Very high

Table 6 shows the results of the evaluation of the Buddhism innovator characteristics of the novice students after learning with the PjBL system in the metaverse, which were gained by means of the 3-rating scale authentic assessment and rubric score. It can be clearly seen that the mean score of these novice students is at a very high level (mean score = 10.59) or over 80% (percentage = 88.27), which is corresponding to hypothesis 3. There exists an interesting point in the research results; that is, the PjBL system in the metaverse contains the learning steps and learning activities that encourage learners to link information, ask questions, observe, experiment, and create a network in order to transfer bodies of knowledge into the metaverse. This is believed to arouse the interest of learners and at the same time enable them to develop the characteristics of Buddhist innovators, leading to the dissemination of Buddhism to the public in Thailand through the said learning steps and learning activities.

Table 7. The satisfaction after learning with the PjBL system in the metaverse for Buddhism innovators in Thailand

Evaluation List	Mean	SD	Level
Contents			
1. Ability to clarify the objectives of the course	4.70	0.47	Very high
2. Ability to facilitate the classroom atmosphere	4.56	0.58	Very high
3. Suitability of contents as to specified objectives	4.63	0.49	Very high
4. Accuracy of contents	4.48	0.51	High
5. Suitability of content composition	4.63	0.49	Very high
6. Sequence of content presentation	4.56	0.51	Very high

(Continued)

Table 7. The satisfaction after learning with the PjBL system in the metaverse for Buddhism innovators in Thailand *(Continued)*

Evaluation List	Mean	SD	Level
Design			
1. Accuracy of presentation	4.63	0.49	Very high
2. Attractiveness of presentation strategy	4.56	0.51	Very high
3. Creativity in instruction design	4.63	0.49	Very high
4. Ability to respond to individual differences and promote students' collaboration	4.63	0.49	Very high
Activities			
1. Consistency of quizzes/exercises and objectives	4.56	0.51	Very high
2. Consistency of instruction activities and objectives	4.56	0.51	Very high
3. Inclusion of group work and individual work in instruction activities	4.63	0.49	Very high
4. Suitability and variety of media in instruction activities	4.59	0.50	Very high
5. Promotion of initiatives, creativity, and discussion	4.67	0.48	Very high
Efficiency			
1. Ease of use and usefulness of learning equipment	4.48	0.51	High
2. Speed and stability of learning tools	3.59	1.05	High
3. Speed and stability of learning software	4.26	0.59	High
4. Speed and stability of network used for learning	4.15	0.72	High
5. Flexibility and convenience of connection to devices	4.07	0.73	High
Total average	4.48	0.56	High

As to Table 7, it is found that the overall satisfaction, in 20 items for evaluation, after learning with the PjBL system in the metaverse is at a high level (mean = 4.48, SD = 0.56), which is complying with hypothesis 4. The aforementioned results also confirm that the PjBL system in the metaverse can be employed to promote Buddhism innovator characteristics among learners through self-directed learning thanks to the virtual reality technologies and digital tools that can satisfy the needs of learners, which is complying with the research of Chatwattana et al. [42]. Above all, the PjBL system in the metaverse can encourage learners' engagement in the creation of innovations that can be used to promote Buddhism in an effective manner.

5 DISCUSSION

The development of the PjBL system in the metaverse for Buddhism innovators in Thailand is based mainly on the concepts and ideas to establish the learning process that can equip learners with the 21st-century skills, such as problem-solving skills and critical thinking skills. The system developed in this study focuses particularly on the project-based learning process and design thinking with an aim to help learners find out creative strategies to create their own works under digital learning environments. In addition, the PjBL system in the metaverse was developed on the Spatial.io platform, and it is compatible with a variety of interactive displays (Responsive Web Design); this will enable learners to gain new bodies of knowledge more quickly, and in the meantime they can change the styles of learning as to their needs. Also, the learners who use this system are expected to develop knowledge and skills, particularly those beneficial to the dissemination of Buddhism to the public, by means of technologies and platforms in the virtual world, which can facilitate immersive learning consistent with the Age of New Normal.

According to the study results, it is found that (1) the learning achievement after learning with the PjBL system in the metaverse is higher with statistical significance at .01, (2) the score of Buddhism innovators is at a very high level or over 80%, and (3) the satisfaction after learning with the PjBL system in the metaverse is at a high level. The results are in accordance with all research hypotheses and comply with the research of Sapliyan et al. [10], who said that the use of technologies and platforms in the virtual world, as well as the New Normal teaching platforms as the tools to promote self-directed learning, can lead to the creation of young innovators in the digital age. Young innovators are those who possess ability to think and devise innovations and generate new bodies of knowledge that can be put to practical use. Additionally, the system can enhance learning achievement for users because the application and utilization of technologies and digital tools to support learning and education management in Thailand can facilitate the learning styles that match with users' needs and, meanwhile, can promote continuous learning as well. It is also in line with the research of Chatwattana et al. [43], who stated that the use of new technologies to create enjoyable educational experiences can promote and encourage learning in higher education since these modernized technologies can facilitate effective communication that can be accessed anywhere and anytime. It is believed that this will result in the proactive communication through which learners are able to interact with one another in real time.

Furthermore, the results are also consistent with the research of Phunaploy et al. [16], who applied the design thinking process to design the learning process used in the online instruction, consisting of three stages (inspiration, ideation, and implementation) for producing creative products. It is found that learners can receive learning experiences from practices that are relevant directly to their own experiences, and thanks to the online lessons, learners are able to learn anywhere and anytime. Not only that, the utilization of existing technologies allows learners to communicate and collaborate through social networks, which is believed to lead to the learning society and the creation of creative, innovative media. In addition, the results are in consistency with the research of Klahan and Ponegrn [22], who integrated the five steps of the design thinking process (empathize, define, ideate, prototype, and test) with the six steps of project-based learning management (preparation, problem definition, planning, implementation, conclusion and discussion, evaluation) with an attempt to develop the learning activities that can promote the characteristics of innovators, support collaboration and, meanwhile, encourage learners to understand the problems in different situations and then solve them by taking action. It is evident from the study results that the learners have acquired a good level of innovator skills (questioning, observation, interaction, testing, cognitive linkage), and the said skills can also promote the creation of innovations arising from practical actions at a good level as well.

6 CONCLUSION

This study is related mainly to the development of the PjBL system in the metaverse and the study of its results. The main objective of this study is to promote the characteristics of Buddhism innovators in four aspects, i.e., 1) observation and questioning, 2) creation of a Buddhist network, 3) creative innovation, and 4) cognitive linkage, which contribute to the development of creative innovations. Furthermore, this study is intended to enhance learners' competencies through project-based learning and design thinking and transfer bodies of knowledge through appropriate technologies in an efficient manner by making the ultimate use of innovations and digital

technologies about the new normal virtual environments in the management of education in Thailand. It is expected that this shall lead to the creation of Buddhist innovators who are able to promote and disseminate Buddhism to the general public in such a digital age like this.

This study contributes to the enhancement of students' learning achievement and four aspects of Buddhist innovator characteristics, all of which will encourage them to think and fabricate new constructive innovations needed to promote Buddhism while raising their competencies through the project-based learning process and design thinking. Moreover, the PjBL system in the metaverse in this study also promotes life-long learning, elevates the quality of social services, especially in the field of education, and supports interaction and sharing of knowledge via virtual technology. All of these are said to assist Thai people in having limitless access to information sources, which will eventually lead to self-development in terms of knowledge and skills.

7 LIMITATIONS AND FUTURE RESEARCH

This study can be applied as a guideline to further develop other project-based learning systems in the metaverse through design thinking for Buddhism innovators, which can help promote not only Buddhism in Thailand but also informal learning through the simulated virtual environment, making learners feel as if they were learning in the physical world. Nonetheless, this study still has some limitations. First of all, the research methodology relies on the single pre-and post-test group, so the usability is limited, and it is insufficient to establish the causality. For this reason, in order to confirm the study results and make them more valid, the future studies should be carried out by means of more robust designs with more diverse participants and larger sample groups. For instance, the studies may be conducted with a control group or a quasi-experimental design so as to confirm the suitability of the research. In addition, the developed instruments should be compared with other learning environments in other relevant contexts as well. The other limitation is that the research participants are quite a small sample group with unique characteristics, i.e., the novice students of the Chinese Mahayana sect ($n < 30$). Hence, the findings derived herein are regarded as only pilot study findings, which can be served as a guideline for future development.

In conclusion, the discussion and the limitations mentioned above can be used as guidelines for future studies. This study also plays a vital role in promoting and supporting the dissemination of Buddhism in Thailand through the immersive virtual environment, in which users are able to practice and learn by themselves independently. In addition, users are encouraged to devise the new innovations based on thinking processes and creative strategies. Above all, this study also places an emphasis on the promotion of continuous learning, which can pave ways to the learning society and, meanwhile, develop learning skills needed in the digital age.

8 REFERENCES

[1] R. Rozalina, "Manajemen Pembelajaran digital Melalui Aplikasi Youtube," In *Prosiding: Seminar Nasional Program Pascasarjana Universitas PGRI Palembang*, 2020, pp. 684–694.

[2] S. Yuliani and D. Hartanto, "Digital online learning by using digital storytelling for pre-service teacher students," *International Journal of Language Education*, vol. 6, no. 3, 2022. https://doi.org/10.26858/ijole.v6i3.20408

[3] M. Akkhachat, "Buddhism and innovation," *Journal of Humanities and Social Sciences Nakhonratchasima Rajabhat University*, vol. 2, no. 2, pp. 59–68, 2020.
[4] P. Sitthithammaporn, P. Prichamunee, P. Polwiset, and P. Kongphong, "The study Buddhism in the 21st century," *Journal of MCU Nakhondhat*, vol. 7, no. 11, pp. 440–451, 2020.
[5] Ministry of Education, *National Education Act B.E. 2562 Amendment (No. 2) B.E. 2545 and (No. 3) B.E. 2553*. Bangkok: Prigwhan Graphic, 2010.
[6] P. Chatwattana, "The concept of creative innovation skills for enhancement of Thailand 4.0," *Journal of Industrial Education,* vol. 17, no. 3, pp. 222–229, 2018.
[7] P. Chatwattana, "Massive open online courses model with self-directed learning to enhance digital literacy skills," *International Journal of Engineering Pedagogy (iJEP),* vol. 11, no. 5, pp. 122–137, 2021. https://doi.org/10.3991/ijep.v11i5.22461
[8] Office of the Education Council, *National Education Plan Framework (B.E. 2560–2574)*. Bangkok: Office of the Education Council Ministry of Education, 2016.
[9] G. Demir, H. Argan, and H. Dinç, "The age beyond sports: User experience in the world of metaverse," *Journal of Metaverse,* vol. 3, no. 1, pp. 19–27, 2023. https://doi.org/10.57019/jmv.1176938
[10] S. Sapliyan, P. Chatwattana, and P. Nilsook, "A constructionist, imagineering learning system with the metaverse: A study of learning outcomes at secondary schools in Thailand," *Global Journal of Engineering Education*, vol. 25, no. 2, pp. 90–98, 2023.
[11] P. Nilsook, P. Chatwattana, and T. Seechaliao, "The project-based learning management process for vocational and technical education," *Higher Education Studies,* vol. 11, no. 2, 2021. https://doi.org/10.5539/hes.v11n2p20
[12] A. Suvandy, P. Chatwattana, and P. Nilsook, "The micro-learning activities via metaverse platform: The outcomes of students' at Pakse Teacher Training College, Lao PDR," *TEM Journal,* vol. 13, no. 2, pp. 1675–1683, 2024. https://doi.org/10.18421/TEM132-80
[13] K. Sisamud, P. Chatwattana, and P. Piriyasurawong, "The project-based learning using design thinking model via metaverse to enhance Buddhism Innovators," *Higher Education Studies,* vol. 13, no. 3, pp. 10–17, 2023. https://doi.org/10.5539/hes.v13n3p10
[14] S. M. Park and Y. G. Kim, "A metaverse: Taxonomy, components, applications, and open challenges," *IEEE Access,* vol. 10, pp. 4209–4251, 2022. https://doi.org/10.1109/ACCESS.2021.3140175
[15] R. O. Flores-Castañeda, S. Olaya-Cotera, and O. Iparraguirre-Villanueva, "Benefits of metaverse application in education: A systematic review," *International Journal of Engineering Pedagogy (iJEP),* vol. 14, no. 1, pp. 61–81, 2024. https://doi.org/10.3991/ijep.v14i1.42421
[16] N. Phunaploy, P. Chatwattana, and P. Piriyasurawong, "The results of development of the online instruction with design-based thinking for the construction of creative products," *TEM Journal,* vol. 10, no. 4, pp. 1715–1720, 2021. https://doi.org/10.18421/TEM104-30
[17] R. J. Yedra and M. A. A. Aguilar, "Design thinking: Methodological strategy for the creation of a playful application for children with dyslexia," *Informatics,* vol. 9, no. 1, 2022. https://doi.org/10.3390/informatics9010001
[18] T. Brown, "Design thinking," *Harvard Business Review,* vol. 86, no. 6, pp. 84–92, 2008.
[19] J. Dyer, H. Gregersen, and C. M. Christensen, *Innovator's DNA: Mastering the Five Skills of Disruptive Innovators*. Massachusetts, MA: Harvard Business Review Press, 2011.
[20] T. Woods, "The 5 skills of the innovators," LinkedIn, 2016. [Online]. Available: https://www.linkedin.com/pulse/5-skills-innovator-tim-woods [Accessed: Sept. 27, 2024].
[21] K. Ri, Y. Wang, J. Wang, J. MA, and J. Xiao, "How do we cognize innovators' special traits? An empirical analysis based on innovation DNA," in *IEEE International Conference on Management Science and Engineering (ICMSE)*, 2019, pp. 304–310. [Online]. Available: https://www.researchgate.net/publication/340862605 [Accessed: Sept. 27, 2024].

[22] P. Klahan and W. Ponegrn, "Development learning activities based on a design thinking process and project based learning to enhance innovators in grade 10 students," *Journal of Education Studies,* vol. 49, no. 2, pp. 1–16, 2021. https://doi.org/10.58837/CHULA.EDUCU.49.2.13

[23] B. Srisa-Ard, *Basic Research*. Bangkok: Suweerivasarn Press, 2013.

[24] T. Khemmani, *Science of Teaching: Knowledge of Efficient Learning Process Management*. Bangkok: Chulalongkorn University Press, 2018.

[25] S. Utranan, *Systematic Instructional Management*. Bangkok: Chulalongkorn University, 1982.

[26] M. R. Robert, D. Alan, and H. W. Barbara, *System Analysis and Design*. Hoboken: John Wiley & Sons, 2013.

[27] Z. Ismuwardani, A. Nuryatin, and M. Doyin, "Implementation of project based learning model to increased creativity and self-reliance of students on poetry writing skills," *Journal of Primary Education,* vol. 8, no. 1, pp. 51–58, 2018. https://doi.org/10.15294/jpe.v8i1.25229

[28] E. Indrawan, N. Jalinus, and S. Syahril, "Review project based learning," *International Journal of Science and Research,* vol. 8, no. 4, pp. 1014–1018, 2018. [Online]. Available: https://www.researchgate.net/publication/332555753_Review_Project_Based_Learning [Accessed: Nov. 3, 2024].

[29] M. Bron and M. G. Barrio, "Project-based learning for teaching transmedia communication," *Journal of Problem Based Learning in Higher Education,* vol. 17, no. 1, pp. 141–151, 2019. https://doi.org/10.5278/ojs.jpblhe.v0i0.2405

[30] N. Chaijum and T. Hiranyachattada, "Integrated learning and project-based learning for project of electrical measurement and instrumentations in electrical engineering course," *European Journal of Science and Mathematics Education,* vol. 8, no. 1, pp. 6–11, 2020. https://doi.org/10.30935/scimath/9543

[31] P. Guo, N. Saab, L. S. Post, and W. Admiraal, "A review of project-based learning in higher education: Student outcomes and measures," *International Journal of Educational Research,* vol. 102, p. 101586, 2020. https://doi.org/10.1016/j.ijer.2020.101586

[32] Y. Yulhendri, A. Sudjatmoko, R. Sofya, and M. Ritonga, "Project-based learning model towards students' P21 skills in the 21st century: In a systematic literature review," *Advances in Economics, Business and Management Research,* vol. 192, pp. 230–240, 2021.

[33] A. Susilawati, H. Hernani, and P. Sinaga, "The application of project-based learning using mind maps to improve students' environmental attitudes towards waste management in junior high schools," *International Journal of Education,* vol. 9, no. 2, pp. 120–125, 2017. https://doi.org/10.17509/ije.v9i2.5466

[34] J. Sandars and G. Poh-Sun, "Design thinking in medical education: The key features and practical application," *Journal of Medical Education and Curricular Development,* vol. 7, pp. 1–5, 2020. https://doi.org/10.1177/2382120520926518

[35] J. A. Juan and R. M. Jesús, "Driving maps: El uso de mapas mentales para orientar el Aprendizaje Basado en Proyectos a través del Design thinking," *Grafica,* vol. 6, no. 11, pp. 25–31, 2018. https://doi.org/10.5565/rev/grafica.92

[36] C. Ukagwu and S. Gray, "Applying the principles of design thinking to the intensive care environment," *University of Toronto Medical Journal,* vol. 100, no. 1, pp. 12–13, 2023. https://doi.org/10.33137/utmj.v100i1.40352

[37] J. Supachaisamanpun, "A study of design thinking for improving employee performance in Bangkok specialty coffee shops," M. S. Thesis, Faculty of Architecture and Planning, Thammasat University, 2019.

[38] P. Noipinit, "An action research on developing instruction on Conic sections topic through design thinking process to enhance creative problem solving ability of 10th grade students," M. S. Thesis, Naresuan University, 2017.

[39] L. Qiang, L. Ze-xue, W. Peng, W. Jing-jing, and L. Tian, "The influence of art programming courses on design thinking and computational thinking in college art and design students," *Education and Information Technologies,* vol. 28, pp. 10885–10902, 2023. https://doi.org/10.1007/s10639-023-11618-7

[40] P. Chatwattana, W. Wongwiwat, and P. Suwankan, "The learning outcomes of total learning experience (TLE) to support digital empathy and literacy skills," *Global Journal of Engineering Education,* vol. 26, no. 1, pp. 26–34, 2024.

[41] T. Saiseenin, T. Nern-Ngarm, and P. Chatwattana, "The outcomes of the development of an immersive virtual reality environment laboratory based on the VRChat platform," *World Transactions on Engineering and Technology Education,* vol. 22, no. 2, pp. 122–128, 2024.

[42] P. Chatwattana, P. Yangthisarn, and A. Tabubpha, "The educational recommendation system with artificial intelligence chatbot: A case study in Thailand," *International Journal of Engineering Pedagogy (iJEP),* vol. 14, no. 5, pp. 51–64, 2024. https://doi.org/10.3991/ijep.v14i5.48491

[43] P. Chatwattana, P. Saisong, K. Rojanapasnichwong, and W. Khiankhokkruad, "The virtual laboratory learning environment: VLLE on metaverse for university in Thailand," *International Journal of Engineering Pedagogy (iJEP),* vol. 13, no. 5, pp. 30–41, 2023. https://doi.org/10.3991/ijep.v13i5.38565

9 AUTHORS

Kiattisak Sisamud is a Teacher at the Office of the General Buddhist Education 13, Bangkok, Thailand. His teaching experience includes educational technology and computer technology. His research interests include educational technology and instruction technology (E-mail: jerambo2@gmail.com).

Pinanta Chatwattana is an Associate Professor at the College of Industrial Technology, King Mongkut's University of Technology North Bangkok, Bangkok, Thailand. Her research interests include educational technology, multimedia technology, instructional design, information and communication technology for education, and applied information and communication technology for instruction. She has experience in design and developing instruction media and developing online learning platform (E-mail: pinanta.c@cit.kmutnb.ac.th; ORCID: https://orcid.org/0000-0002-7749-530X).

Pallop Piriyasurawong is a Professor at the Division of Information and Communication Technology for Education, King Mongkut's University of Technology North Bangkok, Bangkok, Thailand. His expertise is predominantly in education technology, and information and communication technology (E-mail: pallop.p@fte.kmutnb.ac.th).