PAPER

The Virtual Laboratory Learning Environment: VLLE on Metaverse for University in Thailand

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ABSTRACT

The virtual laboratory learning environment on metaverse, or VLLE on metaverse, is a kind of learning media in the virtual world, which can be accessed through a virtual laboratory in the form of metaverse. To enter VLLE on metaverse, users must simulate themselves in the form of 3D avatar, and then they are able to perform any tasks and interact with any objects or surrounding environments therein, which are all virtual images. The study question of this research focuses on the steps and methods related to the development of media for use in VLLE on metaverse and on what design features are satisfactory and would be well accepted by participants. In this study, the researchers have applied concepts and new teaching innovations that correspond to the current situations and can support the learning formats that can be done anywhere and anytime. This practice is believed to promote self-directed learning experiences and other skills while allowing students to evaluate their activities on their own as well. The research results are in line with the researchers' expectations: it was found that VLLE on metaverse can be used as a public interaction tool through mobile applications for the university population and the general public outside. This is because new technologies have been developed and employed in the media and the existing technologies in such a way that an environment close to the real learning conditions can be produced, which can create a learning society without borders.

KEYWORDS

virtual laboratory learning environment, metaverse, avatar, public interaction, new normal

1 INTRODUCTION

In the era of "New Normal," the application of technologies to support learning is considered one of the alternatives for both instruction and business operations. Many educational institutes have employed virtual technology in current instruction management [1] and in distance education, which are designated particularly for those who have differences in individual characteristics and those who intend to equip themselves with knowledge of different fields by means of lifelong learning. Nonetheless, it is believed that the traditional classroom and educational

environment cannot facilitate the aforementioned learning styles. Moreover, more and more people tend to prefer distance learning due to the health issues and the pandemic of COVID-19 [2]. For this reason, the introduction of varied contemporary technologies to respond to the changing contexts of the "New Normal" world can bring activities in which everyone manages to interact with one another in real time [3]. In addition, online-based collaborative learning can create relationships that are believed to enable the increased speed of learning [4].

The virtual world offers a new style of learning that can fulfill the needs of students in the digital age. Technologies and innovations are usually utilized to support instruction so that students are encouraged to learn and do activities together via mobile devices and 3D-rendering devices [3]. Education today relies more and more on innovations and technologies with an attempt to open up better education opportunities, reduce time and place constraints, and promote full-potential learning through media and technologies that can provide environments close to learning conditions in the physical world, which are believed will eventually create a learning society without borders [5].

A new dimension of learning without borders usually refers to the creation of the real-world environment aided by technologies, which can lead to a virtual community [6]. This can be achieved by using technologies to support and stimulate interest and enthusiasm, allowing students to do activities together through virtual environments close to those in the physical world. As a result, a learning society called "Virtual World Learning Community" shall be created [7], together with unlimited experiences that can help promote learning through digital technologies in the world of New Normal.

1.1 Literature and related research studies

The virtual learning environment is a collaborative platform that enables more enhanced learning and more efficient operation; at the same time, it enables students to do activities together from anywhere and anytime, which is suitable for learning in the digital age. Today's virtual learning environment is changing due to the rapid technological advancements [8], [9], which are regarded as a positive factor to help Thailand move towards Thailand 4.0, especially in the areas of learning design and learning on digital platforms [6] stated in Thailand's 20-Year National Strategy in the category of human resource development [10]. This is because students are able to learn anywhere and anytime, while instructors are responsible for allocating the right and appropriate environments for students.

Virtual world reality is a world in which users must simulate themselves in order to enter the 3D environment. In such a 3D environment, users can interact with objects or surroundings in the form of simulated virtual images with the aid of 3D virtual reality devices. Virtual reality (VR) technology is an environment simulated by means of a 3D computer graphic system, in which users can interact instantly with virtual environments using either standard input devices or multi-dimension devices [1]. Virtual reality technology is divided into three types [11], i.e., Fully-immersive VR, Semi-Immersive VR, and Non-Immersive VR (or Desktop VR).

The virtual laboratory is a kind of instruction management that is quite popular in the era of Education 4.0, designated especially for the 21st-century students. The virtual laboratory relies on technological advances together with high-performance computer programs to create simulations in an online format, in which students can access [12] and perform the tasks on their own. This helps support instructional activities by allowing students to have more engagement. Additionally, information technology is utilized in order to provide students with learning experiences,

allowing them to have direct interaction by themselves. Realistic simulation is another characteristic of the virtual laboratory, which is believed to create interest and motivation both to learn and to explore [13].

Metaverse is a new dimension of borderless education management that uses the enhanced virtual technology to provide access to resources and allow users to exchange information therein through a 3D virtual world [14]. In the metaverse, activities are organized in an immersive learning environment combining physical and digital realities across technological tools such as augmented and virtual realities [15], which helps students to achieve deep learning through their self-learning experiences [7]. Due to the rapid growth of technologies and the rapid evolution of data presentation via virtual environments, metaverse is a new dimension of education management, which is in compliance with the concept of New Normal and can promote continuous learning.

1.2 Purpose and hypothesis of research

According to the concepts above, the researchers have an idea to develop the virtual laboratory learning environment on metaverse, or VLLE on metaverse, so as to be used as virtual learning media in 3D format for the audience, both in and outside the university, so that they can receive the most correct and comprehensive information. Furthermore, the researchers are determined to promote learning that can be conducted anywhere via virtual learning environments by making use of the present technologies. Meanwhile, it is expected that VLLE on metaverse corresponds to the communication in the digital age, which can promote learning with no limits and lead to a learning society in digital universities to encourage students to have interaction and engagement with objects or environments that are created realistically by effective and affordable tools and technologies. The research tools consist of (1) VLLE on metaverse and (2) an evaluation form to measure satisfaction with the development of VLLE on metaverse. The statistics used in data analysis are mean and standard deviation.

The main objective of this research is to develop the virtual laboratory learning environment, or VLLE on metaverse, which can be accessed by using avatars. VLLE shall be used as 3D media with the aid of virtual technology, which can promote access to helpful information, borderless learning through mobile application, and engagement in interaction in different situations using the developed learning media.

According to the hypotheses of this research, it is expected that VLLE on metaverse will be accepted by all participants with their consent in terms of efficiency and satisfaction after using it, which will be measured by means of an evaluation form. Also, VLLE on metaverse is expected to be employed as a guideline to further develop any virtual learning models in which metaverse technology and 3D applications are used to create case studies that can promote informal education and continuous self-improvement, corresponding to the policies of student-centered learning and Education 4.0. In the meantime, it is hoped that VLLE on metaverse can pave way to learning society and foster the skills needed for 21st-century students, who are capable of interacting with media and network technology.

2 METHODOLOGY

The development of the VLLE on metaverse concept herein is based on the systematic approach and instructional design of the ADDIE model [16], [17], which concerns the design of learning and development processes in a systematic way such

that it can create effective learning experiences. This model consists of five steps: analysis, design, development, implementation, and evaluation. Blender, a 3D virtual media development program, is employed to create realistic appearance and dimensions, allowing users to interact with the developed learning media. The VRChat application is also used as a medium to simulate the real situations and allow users to have engagement with learning media in the developed virtual environment.

The research methodology is based on the theories of design and development of multimedia materials and animation [18], the theories of the ADDIE model [16], [17], and the five steps of work process [19]. The methodology can be summarised by the following four phases.

2.1 Phase 1: Synthesis of conceptual framework for the development of VLLE on metaverse

The development of VLLE on metaverse is based on the integration of new technological concepts, with an effort to provide students—who must be simulated themselves in the form of a 3D avatar—with hands-on learning experiences in a virtual learning environment. The concepts and theories include virtual learning environment [6], [8–10], virtual reality technology [1], [11], virtual laboratory [12], [13], metaverse [7], [14], [15], and mobile technology [20], [21]. The conceptual framework of this research is shown in Figure 1.
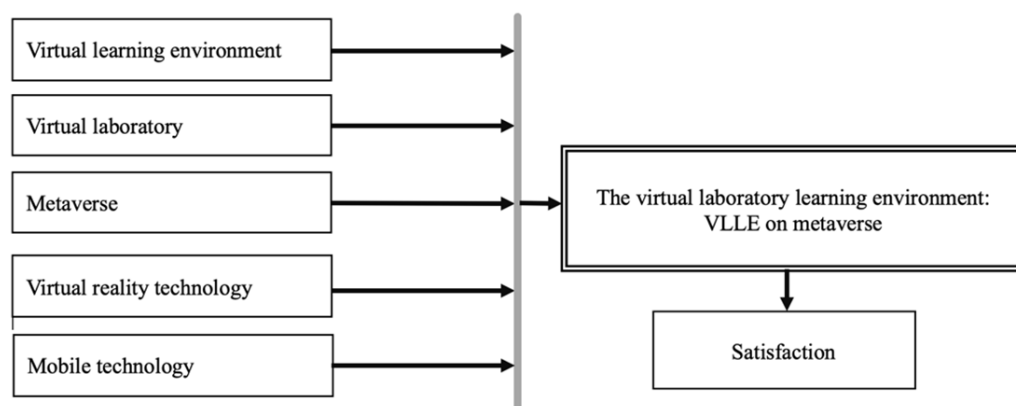

Fig. 1. Conceptual framework of VLLE on metaverse

Figure 1 represents the relationship of concepts involved in the development of VLLE on metaverse, which can be summarised as follows.

The relationship between the virtual learning environment and the development of VLLE on metaverse. The virtual learning environment is a collaborative platform aided by virtual environment. This platform is believed to foster collaborative learning and activities, and it can be accessed anytime and anywhere. The instructors are responsible for managing the appropriate environments in which users can share and exchange their experiences through computer networks. In this research, the emphasis was placed on the study of properties of the virtual learning environment [22] in order to synthesise the guidelines for the design and development of VLLE on metaverse so that it shall be suitable for learning management for students in the digital era.

The relationship between the virtual laboratory and the development of VLLE on metaverse. The virtual laboratory is a format of instruction management

focusing on the creation of online simulations that allow students to access and interact with learning materials or learning tools provided therein. Learners have freedom to learn, seek knowledge and experiences, and set their own learning plans according to their aptitude and competence. In this study, the elements of virtual laboratory were studied with an aim to synthesise the components in the development of VLLE on metaverse.

The relationship between metaverse and the development of VLLE on metaverse. Metaverse is a virtual environment created by means of digital technology, and it can be accessed by using human representatives, called "avatars." In such a virtual world, users can interact and collaborate with one another with the aid of virtual reality (VR) or augmented reality (AR) wearables, allowing students to have deep learning through their first-hand experiences. This study focused on the features and technologies that make metaverse so realistic and practical.

The relationship between virtual reality technology and the development of VLLE on metaverse. Virtual reality technology is a technology that connects users to the digital world by using input devices and 3D display devices. Users can interact instantly with the simulated virtual environment. This study emphasised the relationship between virtual reality technology and metaverse technology as well as other related theories in order to find out the suitable virtual reality model for the development of VLLE on metaverse.

The relationship between mobile technology and the development of VLLE on metaverse. Mobile technology is considered a new dimension of learning in the world of "New Normal," in which everybody is able to learn anywhere and anytime via internet just by using devices. In this study, the benefits and limitations of mobile technology, once employed with virtual laboratory learning environment, were examined with an aim to synthesise the guidelines for the design and the development of VLLE on metaverse.

The relationship between satisfaction and the development of VLLE on metaverse. Satisfaction is the outcome obtained in the form of attitudes and feelings that arise when the expected results are achieved. This research studies the satisfaction after using the VLLE on metaverse by asking the users to answer questions (confidentially and anonymously) in an evaluation form. The feedback was used to improve the performance of the VLLE on metaverse.

In addition to the concepts above, the researchers also studied Blender, which is a widely popular program used to create and develop 3D virtual learning media. This program has an outstanding feature that enables users to interact with the virtual environment through a variety of functions under the program's platform. The researchers conducted in-depth interviews directly with the users, asking them about their real needs, in order to obtain the conceptual framework for the development of VLLE on metaverse, which can satisfy their needs in terms of both learning and usability.

2.2 Phase 2: Design of VLLE on metaverse

In this phase, the researchers studied the structure of a real laboratory, as well as its associated environments, and then conducted the structural design by using SketchUp, a popular 3D modeling program for architecture, engineering, interior design, and product design, in order to obtain the layout as close as possible to the prototype and the real laboratory. Furthermore, the researchers applied the theories of design and development of multimedia materials and animation [18] as a guideline for research design, which consist of five elements: Balance, Unity, Color, Flow, and Interaction.

2.3 Phase 3: Development of VLLE on metaverse

In this stage, the researchers employed the theories of the ADDIE model [16], [17], and the five steps of work process [19] as a guideline to develop VLLE on metaverse. Blender, a 3D virtual media development program, was employed to create a realistic appearance and dimensions. The VRChat application was also used as a medium to simulate the real situations and allow users to have engagement with learning media in the developed virtual environment.

2.4 Phase 4: Study of the results after using VLLE on metaverse

The researchers used the research tools to study the satisfaction of the participants with the developed learning media. There were 20 research participants: 9 females and 11 males, age 15–30 years, who were professors, personnel, and students of King Mongkut's University of Technology North Bangkok, as well as the general public outside the university, all of whom were derived by means of cluster sampling. All of the participants gave their consent to take part in this research, and they were willing to answer the evaluation form with confidentiality and anonymity.

3 THE VIRTUAL LABORATORY LEARNING ENVIRONMENT: VLLE ON METAVERSE

The virtual laboratory learning environment via metaverse (VLLE on metaverse) originated from the combination of new technology concepts, with an aim to create new innovations that can support learning styles for the world of New Normal while providing students with hands-on learning experiences. The simulation of an environment of the physical world by means of combined technologies, leading to a virtual learning community, is regarded as a new dimension of borderless education. To achieve this, the virtual reality technology was applied so that users could directly interact with objects or environments that were created realistically by effective and affordable tools and technologies. The results of the development of VLLE on metaverse can be summarised as follows.

3.1 Results of the design of VLLE on metaverse

The layout of VLLE on metaverse was designed by means of the program SketchUp and imported with the program Blender. Both are popular 3D modeling programs that can render the layout as close as possible to the prototype and the real laboratory. In addition, the theories of design and development of multimedia materials and animation were applied as a guideline for research design. The elements in the designed VLLE on metaverse included three virtual laboratories, as follows: (1) Studio laboratory, which is a laboratory for filming and broadcasting television programs. The laboratory consists of many tools and equipment necessary for filming and broadcasting, as in a television station. Users can engage in and interact with any actions within such simulation, e.g., backdrops, lighting systems, television cameras. (2) Macintosh laboratory, which is designated for instruction

with the assistance of some applications. It consists of some facilities that are used to promote learning, e.g., Macintosh computers, projectors, TVs, interactive boards. (3) Lecture classroom, which is created for both theory and practical class learning related to electronics. This laboratory comprises such facilities as projectors, TVs, and interactive boards. To access and use or interact with the equipment and tools available in the three virtual laboratories, users must simulate themselves into avatars. This can help students feel like they are at the campus with familiar environments, like in the physical world. The layout design of VLLE on metaverse is shown in Figure 2.
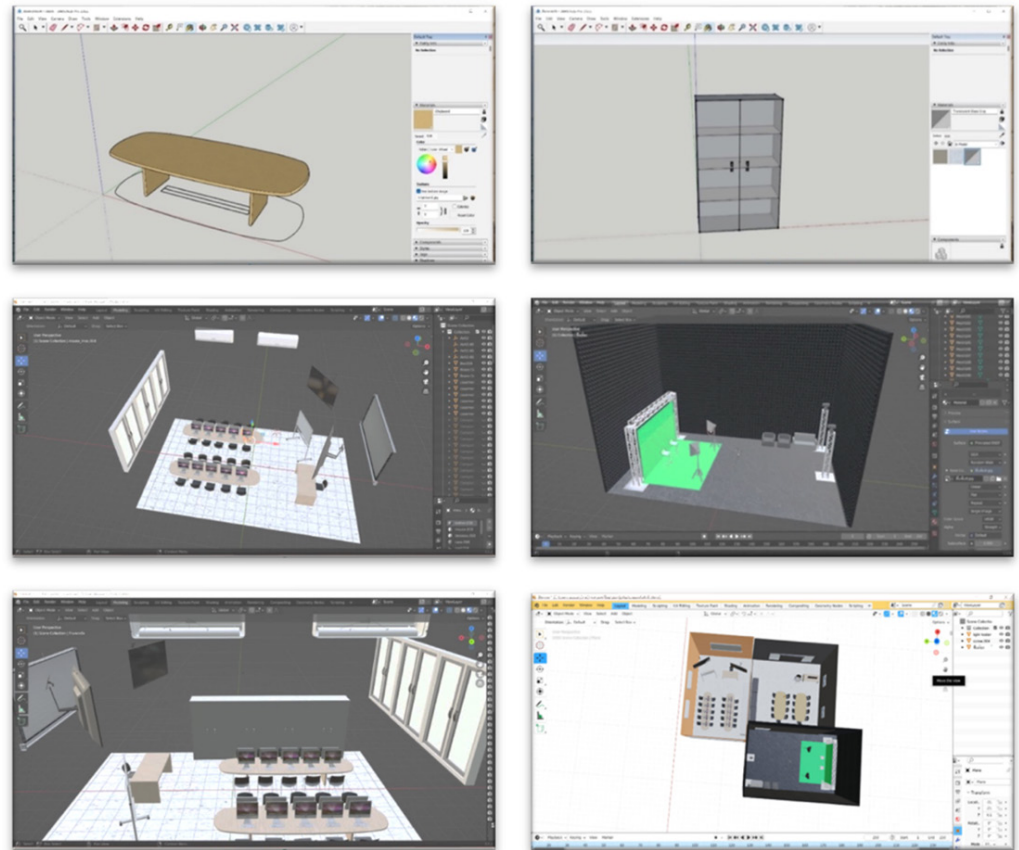

Fig. 2. Layout design of VLLE on metaverse

3.2 Results of the development of VLLE on metaverse

In order to develop VLLE on metaverse, the researchers employed the theories of the ADDIE model and the five steps of work process [19], i.e., login, navigation, interaction, evaluation, and logout, as a guideline for development so that VLLE on metaverse could support the learning as much as possible. Additionally, a 3D virtual media development program, Blender, was employed and the VRChat application was also used as a medium to simulate the real situations and allow users to have engagement with learning media in the developed virtual environment. VLLE on metaverse is illustrated in Figure 3.
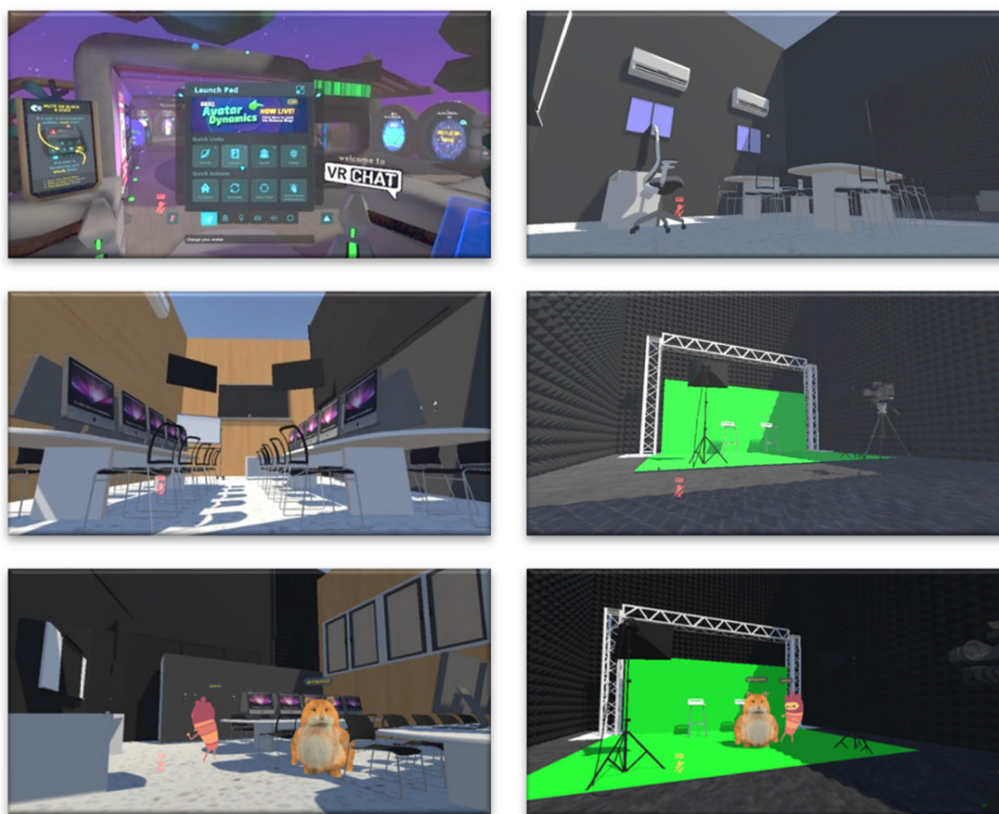
Fig. 3. VLLE on metaverse

Figure 3 shows the learning media in VLLE on metaverse, which students could access through the VRChat application. By this method, students could use the equipment and tools available in the three virtual laboratories (Studio laboratory, Macintosh laboratory, and Lecture classroom). This allowed students to participate in a virtual world (with a virtual university environment) and make use of emerging technologies in such a virtual world. This is regarded as a new dimension of learning management with no borders, which is believed to provide limitless experiences through digital technology.

3.3 Results after using VLLE on metaverse

After developing VLLE on metaverse, the researchers had the participants use it and then studied their satisfaction with the developed learning media in terms of design and efficiency. There were 20 research participants: 9 females and 11 males, age 15–30 years, who were professors, personnel, and students of King Mongkut's University of Technology North Bangkok, as well as the general public outside the university.

All of the participants gave their consent to take part in this research, and they were willing to answer the evaluation form with confidentiality and anonymity. For data collection, the researchers employed an evaluation form that had been reviewed with Index of Consistency (IOC), which is the correspondence between

question and objective by the experts. The participants were asked to complete form with their consent. Before this stage, the researchers had given them detailed information along with the documents relevant to the study and let them decide whether they would join the study or not. The participants were informed that their personal information would be kept confidential and anonymous. In addition, the participants were given the detailed and complete information about this evaluation, together with its objectives, and they were allowed to ask any questions about anything they did not understand. The results are summarised in Table 1.

Table 1. Results of evaluation on the satisfaction with the use of VLLE on metaverse

Items for Evaluation		Results		Interpretation
		Mean	SD	
Design	1. Creativity and attraction	4.85	0.47	Very high
	2. Convenience of visiting	4.60	0.52	Very high
	3. Modernity and up-to-date technologies	4.95	0.46	Very high
	4. Realism of the virtual laboratory	4.70	0.52	Very high
	5. Resolution of the virtual laboratory while visiting	4.70	0.52	Very high
	Overall design	4.76	0.50	Very high
Efficiency	6. Content validity and consistency of image sequences	4.75	0.54	Very high
	7. Suitability for future application	4.70	0.56	Very high
	8. Easy accessibility via VRChat program	4.90	0.30	Very high
	9. Problems arising while visiting	3.35	0.48	Moderate
	Overall efficiency	4.43	0.47	High

In reference to Table 1, the results of evaluation on the satisfaction with the use of VLLE on metaverse can be divided into two aspects: (1) the overall satisfaction in terms of design was at very high level (Mean = 4.76, SD = 0.50), and (2) the overall satisfaction in terms of efficiency was at high level (Mean = 4.43, SD = 0.47). According to the results, it was found that the VLLE on metaverse can be applied through VRChat application as media for self-learning and for public interaction in a university because it enables the students to feel as if they were in the real university environments. This is consistent with the research of Laberiano et al. [23], who researched the creation of virtual courses for training. This can help foster self-learning and develop a vision of self-improvement. It is also in accordance with the research of Bazhenova et al. [24], who concluded that mobile learning can lead to improvements in students' learning outcomes, i.e., flexibility and accessibility of learning process ensured by handhelds, diversity of quality content, good visualisations, effective feedback, and favourable conditions for collaboration. It is also in accordance with the research of Muchlas et al. [4], who found that online distance learning makes the learning process more efficient and flexible, and that it also promotes and supports collaborative activities.

4 DISCUSSION AND CONCLUSIONS

The virtual laboratory learning environment via metaverse, or VLLE on metaverse, is considered a tool that can promote public interaction through VRChat application and is compatible with Android and IOS operating systems. The idea of VLLE on metaverse is based on the integration of new technological concepts and theories with an attempt to create new innovations that can support learning styles for the world of New Normal while providing students with hands-on learning experiences. This is believed to lead to a virtual learning community, which is a new dimension of borderless education. To achieve this, the principles of ADDIE model and the five-step workflow were applied to develop the tools that can support the learning as much as possible. Additionally, a 3D virtual media development program, Blender, was employed, and the VRChat application was used as a medium to simulate the real situations and allow users to have engagement with learning media in the developed virtual environment.

Our study on the satisfaction with the developed learning media of VLLE on metaverse in terms of design and efficiency was carried out with 20 participants—9 females and 11 males—age 15–30 years, who were professors, personnel, and students of King Mongkut's University of Technology North Bangkok, including the general public outside the university. It was found that (1) the overall satisfaction in terms of design was at very high level (Mean = 4.76, SD = 0.50), and (2) the overall satisfaction in terms of efficiency was at high level (Mean = 4.43, SD = 0.47). It can be clearly seen that VLLE on metaverse can be employed as media for self-directed learning and as public interaction media for students and people both in and outside the university through the VRChat application. This enables students to feel as if they were in the real university environments. This is consistent with the research of Chatwattana et al. [5], who found the combination of new technology concepts and new teaching methods to create the brand-new ideas and innovations by providing an appropriate environments and suitable learning media for students can encourage students to have more engagement in the learning process and enable them to have instant interaction with others and follow up on their results at any time. It is also in accordance with the research of Demir et al. [25], who stated that the metaverse is a new technology that can enhance interactive experiences in the virtual world. It paves the way to active learning through media and information technology, which is thought to enable students to obtain learning experiences on their own.

This research can be employed as a guideline to study the development of VLLE on metaverse to encourage informal and active learning in environments that make learners feel as if they were in a real-world university. Nevertheless, there is still a limitation in this research: the number of research participants was too small. As a result, our findings derived should be considered a pilot study, to be used as a guideline for future development. Future studies should be conducted with a larger sample group along with additional tests in order to compare the developed model with other formats of learning environments and study the effectiveness of VLLE on metaverse in other relevant contexts.

5 ACKNOWLEDGMENT

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