The outcomes of the development of an immersive virtual reality environment laboratory based on the VRChat platform

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ABSTRACT: The immersive virtual reality environment laboratory (IVREL) is a tool to promote learning in the virtual world through the VRChat platform. The IVREL is compatible with both the Android and IOS operating systems, and users can only enter it as 3D avatars to be able to engage and interact with virtual objects and perform tasks - the whole setting being similar to the physical environment of a university. The main objective of this research was to develop the IVREL using virtual reality technology through access, interaction and practice within virtual environments, leading to new skills acquisition which are the learning outcomes of the IVREL usage. As part of this development, the opinions of 50 IVREL users participating in this research, have also been gauged. The findings indicate that the process involved, the structure, the overall design and efficiency of the IVREL are sound, and it can be used as a tool to provide easy access to virtual environments and enable users through the VRChat platform to learn and practise by themselves.

INTRODUCTION

Learning in the virtual world is regarded as a new format of learning that resonates with learners in the digital age because it employs current technologies or platforms to create the so-called immersive learning environment with 3D avatars, which enable the learners to respond and interact with others in real time via mobile and 3D devices [1].

Recently, several institutions have utilised virtual technology in their learning management in an attempt to create virtual environments similar to those in the real world, which may lead to creating a learning society called the *virtual world learning community* [2]. This learning style can provide limitless experiences, which will further promote learning through technologies in the new *normal* world since it can reduce the limitations of time and place.

A virtual laboratory has been initiated by the idea of integrating technological advancements with capabilities of today's high-performance computer programs in order to develop simulations in an on-line format, thus enabling learners to access these simulations and do the required tasks by their own [3], and gain direct learning experiences.

Virtual learning environments created by means of such virtual laboratory allow users to interact directly with objects and surrounding environments therein, which are as realistic as those in the physical world, through the tools or platforms at reasonable prices [4]. Studies indicate that this method can stimulate interest and increase enthusiasm for learning [5].

Prasetya et al stated that the use of a virtual laboratory as a practical learning tool with experiments for a better understanding of the learning content can increase learning opportunities, efficiency, and add more value to the curricula [6]. This tool enables learners to do activities together in virtual environments, which is considered a new dimension of learning without borders. Moreover, it is expected that once learners use simulation and as avatars enter an immersive environment, they can engage in deep learning [2] and carry out activities with others, while instructors are responsible for allocating appropriate environments for learners.

Virtual reality (VR) is a virtual technology commonly used for simulating a variety of locations with 3D computer graphics. Advanced educational developers are using virtual reality technology to create virtual environments in order to help users learn and enjoy these kinds of places in a flexible manner [7]. However, in the context of learning, there are some limitations concerning the usage of this technology due to its general, all-inclusive features. Therefore, it is necessary to develop applications with better interactive learning features that can be accessed via smart devices, as fits the digital age. These advancements can directly benefit users by enabling experiences via 3D input and display devices to engage in self-learning through contact with virtual communities. This will help improve their learning competencies and skills, and facilitate the transition to the digital world in the future [8].

VRChat is an on-line virtual reality platform that allows users in the form of avatars to interact with others in the fabricated 3D world [9] via a 3D input/output device. In general, the reality of the 3D world and 3D avatars, compatibility with varied platforms, compatibility with various operating systems, and display ability through interaction screens are the advantageous and often highlighted features of VRChat.

Studies have already demonstrated the potential of virtual reality technology and the platforms that can support education systems through virtual environments with limitless interactivity on a variety of operating systems and compatibility with different user interfaces. Following a thorough literature review of the relevant concepts and theories, the authors of this article developed an immersive virtual reality environment laboratory (IVREL) on the VRChat platform with an aim to encourage students to learn in the 3D immersive environment from any location and at any time suitable to them. The laboratory was developed in the Digital TV station of King Mongkut's University of Technology North Bangkok (KMUTNB Digital TV), Thailand. In the IVREL and with the aid of efficient tools or technologies, students can access the virtual world, practice there and feel as if they were in the familiar university environment of the physical world.

RESEARCH QUESTIONS

This study was intended to examine the perspectives of research participants towards the IVREL. Protected under the policies of confidentiality and anonymity, all of these participants willingly completed an evaluation form, and the results of which were analysed to find out to what extent the IVREL responds to the needs of users, in terms of efficiency and interaction via VRChat. Thus, this study has the following research questions:

RQ1: What is the development process of the IVREL?
RQ2: What are the structures and elements of the IVREL?
RQ3: What are the opinions of the IVREL users/research participants regarding its efficiency and interaction with VRChat?

This research uses the pre-experimental research method and one-shot case study to find answers to the above questions. In order to answer RQ1, the research team relied on the details about the development method and the testing on the efficiency of the IVREL. Regarding RQ2, similarly to RQ1, the details about the design and development of the IVREL were used to explain the structures and elements within the IVREL. To answer RQ3, the evaluation form was employed to examine the perspectives of the participants towards its development, fulfillment of user needs and to provide other useful information.

RESEARCH METHODOLOGY

Research Design

Within the context of the research questions, the research team relied on the research and development approach (R&D), and specifically used the ADDIE model [10], which consists of five stages: analysis, design, development, implementation and evaluation.

For the actual development of the learning media with different dimensions and realistic appearance, the team used Blender, which is a free, open-source tool for making 3D virtual media. The user's ability to interact with the learning media was highly important. Prior to the development, information about the needs of users, especially students, in terms of learning, was collected and then used as a guideline to design and develop the learning media, which was presented through the VRChat platform, allowing users to access the developed virtual environments and learn using the media.

Participants

There were 50 participants in this research, including instructors, staff and students from the College of Industrial Technology at King Mongkut's University of Technology North Bangkok, Thailand. All of these participants were derived by means of cluster sampling and were well protected under the policies of confidentiality and anonymity.

Research Instruments and Data Collection

The instruments used in the data collection included:

1) the immersive virtual reality environment laboratory (IVREL), and
2) the evaluation form on the efficiency of the IVREL.

The statistics used for data analysis were mean and standard deviation. The evaluation form had already been assessed and verified for the index of item-objective congruence (IOC) by experts. The participants were fully informed about the details of the study and the evaluation form, and reassured that they had freedom in accepting this participation. In addition, the research team guaranteed that the participants' identity shall not be disclosed.

Method

The methodology employed in this research refers to the three research questions, and can be divided into four stages, as described below:

RQ1: What is the development process of the IVREL?

Stage 1: Synthesise the conceptual framework for the development of the IVREL. The IVREL is created by the integration of virtual reality technology and an on-line virtual reality platform, which enables users to interact with others through their 3D avatars in the 3D world, providing them with hands-on experiences. The following concepts and objects were analysed to identify information relevant for this study:

- immersive learning environment,
- virtual laboratory,
- virtual reality technology,
- VRChat platform,
- structures and elements of the KMUTNB Digital TV.

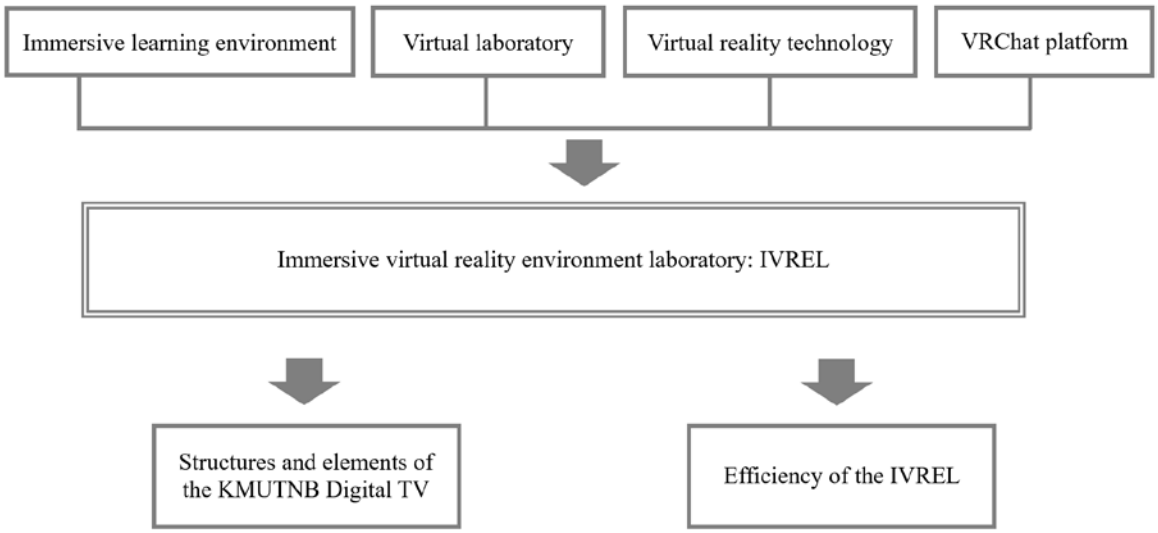


Figure 1: Relationship between concepts and theories of the IVREL.

Besides the above-mentioned concepts and objects, the research team also examined the software program called Blender, which is usually used to create and develop virtual learning media in 3D format. The outstanding feature of this program is that it allows users to interact with the virtual environments through a variety of functions contained in this platform. Therefore, this program is considered an ideal choice for the development of virtual learning media that can provide effective learning to students. Additionally, the research team conducted in-depth interviews directly with Blender users to obtain more information for the conceptual framework of the IVREL, which would satisfy the needs of potential learners.

Stage 2: Design the IVREL. At this stage, the research team studied the structure of a real laboratory, as well as its environments, and then used these data to design the layout of the virtual laboratory with the aid of SketchUp and Blender. In this study, the layout of the IVREL was designed based mainly on the layout of the KMUTNB Digital TV, which consists of two sections: 1) a studio for filming television programmes; and 2) a broadcast control room. The layout was created with a 3D program, so that the IVREL would be identical to the original laboratory as much as possible. The laboratory environments were designed in such a way that they could stimulate the enthusiasm to learn and promote learners' engagement by providing real-time interaction and feedback at any time.

Stage 3: Develop the IVREL. In this part, based on the concepts and the layout which had been designed by means of SketchUp and Blender in stage 2, the research team employed the Blender program to develop the IVREL. They chose this program because it can create learning media with different dimensions and realistic appearance, and make users feel as if they were learning and practicing in the real place. Moreover, this virtual laboratory was presented via the VRChat platform, so that the users could have more engagement in the learning media inserted in the developed virtual environments. Since the research team followed the theoretical principles of Tzeng and Tien [11], the structure and the operation process within the IVREL consist of five steps: log in, navigation, interaction, evaluation and log out.

Stage 4: Examine the results after using the IVREL. The perspectives of the 50 participants towards the IVREL were examined at this stage. The participants included instructors, staff and students in the College of Industrial Technology, King Mongkut's University of Technology North Bangkok, Thailand. All of the participants, 23 females and 27 males,

gave their consent to take part in the research by answering questions in the evaluation form on the policies of confidentiality and anonymity.

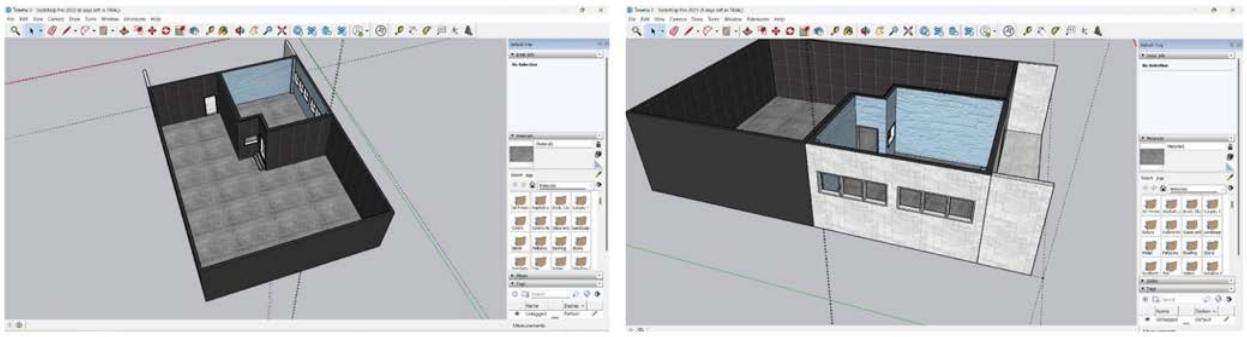
FINDINGS

The findings of this research refer to the extent to which the IVREL is able to respond to the needs of users, in terms of efficiency and interaction via VRChat, hence RQ2 and RQ3 (stages 2, 3, 4) are particularly relevant in this section of the article.

RQ2: What are the structures and elements of the IVREL?

Design of the Immersive Virtual Reality Environment Laboratory

In this stage, in order to accurately depict the structure and physical features of the KMUTNB Digital TV station for education, the research team had thoroughly scrutinised the structure and features of the real places, i.e. the studio for filming television programmes and the broadcast control room, by carefully measuring the sizes of the rooms, as well as the sizes of the tools and equipment therein before designing their layouts by means of the SketchUp and Blender programs. After that, the layout of the virtual station was created with a 3D program to ensure that the IVREL is similar to the original laboratory as much as possible, as seen in Figure 2a-Figure 2c.



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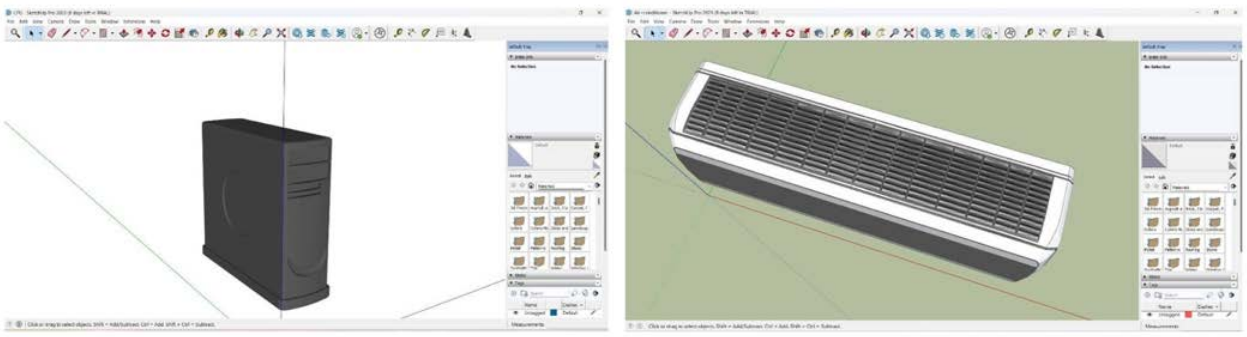

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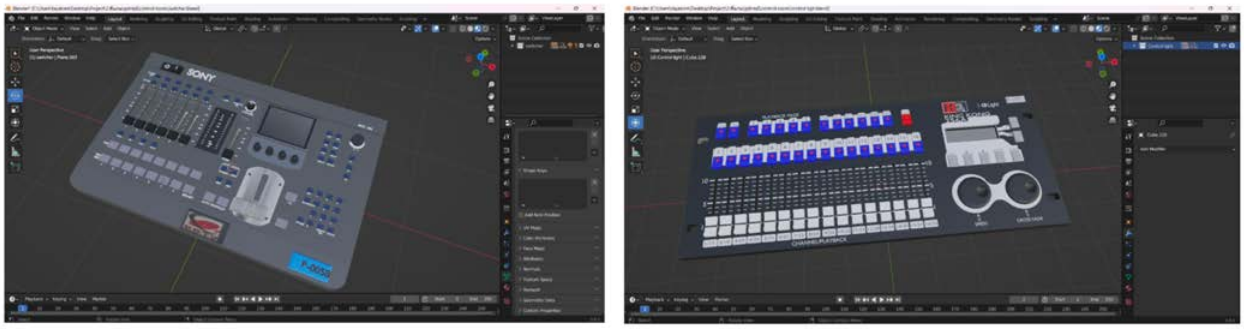


2c)

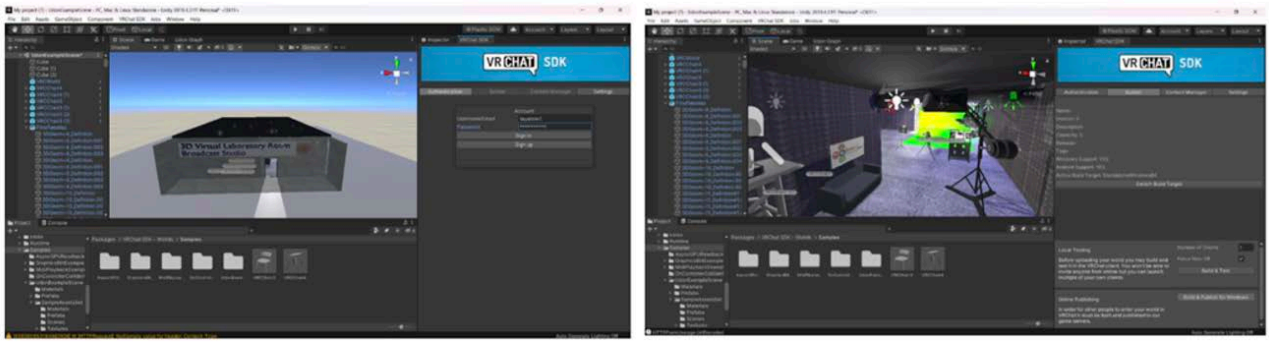
Figure 2: Layout design of the immersive virtual reality environment laboratory.

Development of the Immersive Virtual Reality Environment Laboratory

In the development of the IVREL, the layout design was used as a guideline with the aid of the Blender program to create the learning media with different dimensions and realistic appearance. Throughout the whole development,

the research team put emphasis on creating a virtual place that mirrored the real one as much as possible, so that users could feel as if they were learning and practicing in the real one interacting easily in various environments simulated in the IVREL. In addition, the virtual laboratory was presented via the VRChat platform to ensure more engagement and motivation to learn.

The structure within the IVREL was designed and created in compliance with the measurements of the actual laboratories, the tools and the equipment therein. Furthermore, the research team had investigated the operation processes in the real studios and then with based on that knowledge proceeded to the actual development Figure 3a - Figure 3c.



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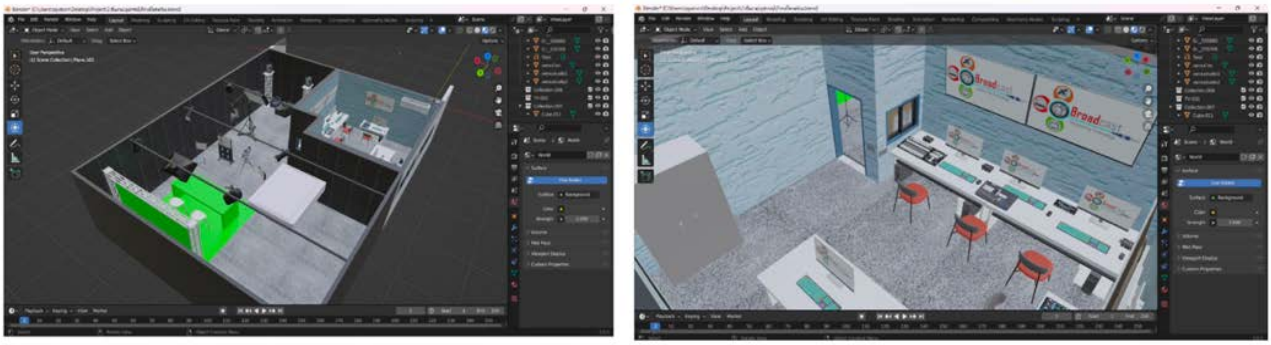

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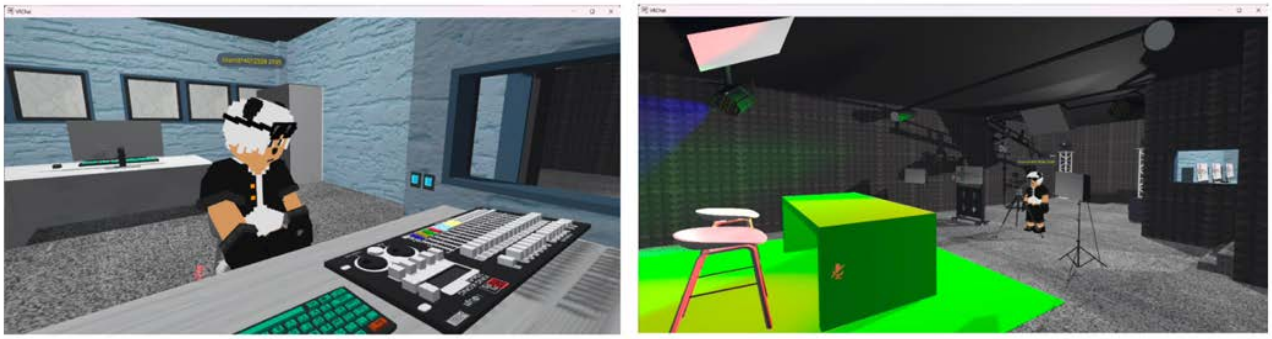

3c)

Figure 3: The IVREL mirroring the KMUTNB Digital TV studio, Thailand.

Efficiency of the Immersive Virtual Reality Environment Laboratory

This study also aimed to evaluate the effectiveness of the IVREL as stated in RQ3:

RQ3: What are the opinions of the research participants after using the immersive virtual reality environment laboratory or IVREL?

All the 50 research participants gave their consent to take part in the study and answer questions in a 5-level rating scale in the evaluation form. The evaluation criteria included the following scale and interpretation [12]:

- 4.50-5.00 points - very high level of efficiency;
- 3.50-4.49 points - high level of efficiency;
- 2.50-3.49 points - moderate level of efficiency;

- 1.50-2.49 points - low level of efficiency;
- 1.00-1.49 points - lowest level of efficiency.

Table 1 demonstrated the results of the design and efficiency evaluation of the IVREL by the participants.

Table 1: Results of the IVREL evaluation - design and efficiency.

Aspect	Items for evaluation	Mean	SD	Interpretation
Design	1. Attractiveness and colourfulness	4.54	0.61	Very high
	2. Creativity and appeal	4.44	0.67	High
	3. Suitability for viewing and usage	4.40	0.73	High
	4. Compatibility with varied devices	4.22	0.89	High
	5. Modernity in terms of design technology	4.64	0.66	Very high
	6. Ability in terms of virtual reality	4.40	0.76	High
	7. Stability of the model during a visit	4.46	0.73	High
Efficiency	8. Ability to interact	4.50	0.65	Very high
	9. Ability to interact with accuracy	4.46	0.71	High
	10. Ability to communicate during a visit	4.40	1.01	High
	11. Ability to view via the VRChat platform	4.42	0.84	High
	12. Ability to display accurate and complete details	4.54	0.73	Very high
Average score		4.45	0.76	High

As shown Table 1, it was found that the overall efficiency of the IVREL is at a high level (mean = 4.45, SD = 0.76). It can be clearly seen that the IVREL is efficient enough to simulate the conditions of the KMUTNB Digital TV station, in which learners are able to access and practice any tasks on their own, while gaining learning experiences directly through the VRChat platform in an effective manner. Additionally, the IVREL can be further utilised as learning media for self-learning and as public relations media for students and those interested, both in and outside the university.

According to the discussion with the research participants after testing the IVREL, it can be concluded that IVREL users are able to interact with virtual environments created to simulate the university environments in the physical world. In other words, the users can use, operate and interact with the objects, tools and equipment in the IVREL in real time. Moreover, it is very convenient for the users to access the IVREL anywhere and anytime because it is compatible with a variety of mobile devices.

DISCUSSION

The results from this research correspond to the main objectives and can answer all the three research questions. When compared with results of earlier studies, it can be concluded that the results of this present research are in line with, for example, the study of Sriadhi et al, who demonstrated that a Web-based virtual laboratory application is a new way to solve the problem of low competencies among students who lack laboratory practice [13]. This is because such Web-based laboratory can help students achieve better outcomes when learning without time or space limitations and at their own pace; also such an application can be used for development in other areas than educational, if desired.

The findings are also consistent with the research of Arouri et al who stated that the creation of e-learning with appropriate teaching strategies in virtual environments (synchronous, asynchronous or blended) and the design of interactive learning activities can enhance technological learning skills [14]. The current findings are also in accordance with the research of Chatwattana et al who pointed out that the virtual laboratory learning environment via the metaverse can be used as media for self-learning and for public relations through the VRChat platform and that this environment can make the participants feel as if they were on campus and in the familiar environment of the real-world university [15]. Furthermore, this form of learning can also lead to creating a learning society in the 21st century, where learners have to be well equipped with essential learning skills, as well as abilities to interact with media and technologies through the network system.

The findings are also consistent with the research of Najib Fahmi et al who stated that the virtual reality laboratory can be used to support practical learning and to improve technological literacy skills via virtual reality technology in which students are able to gain computer-based experiences that can encourage them to expand their knowledge of technology [16].

CONCLUSIONS

The immersive virtual reality environment laboratory (IVREL) is a learning tool that enables users to access and practise the assigned tasks on their own in the virtual environments simulated from the Digital TV station of King Mongkut's University of Technology North Bangkok (KMUTNB Digital TV). The IVREL was developed with the Blender software program because this program allows for the creation of learning media with different dimensions and

realistic appearance to ensure that users feel as if they were learning and practicing in the real world. This virtual laboratory was presented via the VRChat platform, which is compatible with the Android and IOS operating systems, which ensures wide engagement regardless of the used device. By this way, learners can also gain hands-on experience in virtual learning environments, which paves the way to creating a virtual learning community better prepared for virtual education management and borderless learning.

The results of this study can answer all the three research questions. According to the collected data, it was found that the IVREL can be effectively applied as a learning tool that enables users to engage in learning through the VRChat platform. This is because the IVREL offers an opportunity for learners to access and practice any tasks on their own, while gaining learning experiences directly through self-learning in an effective manner. Moreover, the IVREL can be further employed as public relations media for students and those interested, both in and outside the university.

Nevertheless, this study has some limitations as it focuses merely on a specific target group, resulting in a limited usage of the developed laboratory. So, in order to obtain more evidence of the IVREL's efficiency, further studies should be conducted with more diverse participants and more experiments. Based on such studies, the use and efficiency of the developed tool could be measured in other relevant contexts and the overall suitability of the research could be confirmed.

In summary, the research team believe that this development has a vital role in promoting active learning by making use of immersive virtual environments which can be accessed anywhere and anytime. It is expected that this form of learning will make learners feel as if they were in the familiar environment of the real-life university. Above all, it is believed that this development will also contribute to the creation of a learning society with learning skills appropriate to the digital age.

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