A 3D-interactive virtual classroom with a virtual learning environment

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ABSTRACT: A 3D-interactive virtual classroom (3D-IVC) has been developed as a tool to promote learning outside the classroom. This involves combining new technology with new teaching methods, with the aim of creating innovative ways to promote responsive learning for the new generation of learners. Instructors are responsible for arranging the environment and creating suitable learning media for the students, thus leading to a learning society in a digital university. The 3D-interactive virtual classroom was developed through applying the Unity Technologies' cross-platform engine - the Unity3D program - which is used to develop 3D virtual media. The 3D-IVC system simulates reality in appearance and dimensions. Users can interact with the learning media by participating in a virtual simulation of real-life situations.

INTRODUCTION

In education, instructors increasingly are required to place emphasis on active learning. This involves self-learning in the acquisition and extension of knowledge and its application to real-life situations [1[. Digital teaching resources are of great significance in the informatisation of education. The digital teaching environment is based on a multimedia presentation of educational information to express key and abstruse points, and facilitate the conversion of implicit into explicit knowledge [2].

Learning should integrate knowledge in a creative and innovative manner to fulfil the needs of society. Instructors are responsible for arranging the learning environment and creating appropriate instructional media for the students. Innovations in learning should encourage students to develop their learning skills and to actively learn from real experience.

Recent technological advancements producing tools for instructional management enable learners to learn anywhere and anytime. On-line teaching platforms provide a virtual learning environment integrating teaching resources, learning resources and teaching support [3].

Augmented reality (AR) combines the real world with computer-generated virtual information [4[. Users can interact with the virtual objects that overlay the real environment for a more blended and natural experience. Most of the AR applications only allow users to browse the AR content or have minimal interaction, such as moving or rotating a virtual object [5].

An AR application can be an alternative or complement to a constructivist approach to learning; e.g. students can use a smartphone to run an AR application at anytime and in any place [6]. In addition, research shows that AR technology can promote learners' interest and motivation [7], as well as increase spatial awareness and learning [8].

The 3D virtual learning environment can offer new openings for creativity in learning through role play and mentoring. This in turn can support open learning spaces for practice and discovery, experimentation and user-created content [9], which can help learners to visualise in real-time. Therefore, learners can benefit from wireless Internet technology supporting a learning environment. This technological environment as a means of social communications has evolved very rapidly [10] and leads to the concept of the digital university.

Inspired by the above concepts, the researchers decided to develop a 3D-interactive virtual classroom using Unity, a 3D visualisation program. The research involved the design and development of a virtual classroom and investigation of the learners' interaction with the learning media.

RESEARCH OBJECTIVES AND HYPOTHESIS

The objectives of this research were to:

- synthesise the conceptual framework of a 3D-interactive virtual classroom (thus with a virtual learning environment);
- design and develop a 3D-interactive virtual classroom;
- study the use of the 3D-interactive virtual classroom.

The research evaluated the efficiency and satisfaction of the use of the virtual classroom; i.e.:

- Evaluation of the efficiency of a 3D-interactive virtual classroom (with a virtual learning environment).
- Satisfaction of the use of a 3D-interactive virtual classroom.

RESEARCH METHODOLOGY

In this research, a 3D-interactive virtual classroom was employed, guided by the ADDIE (analyse, design, develop, implement, evaluate) model [11], with 3D virtual media to create realistic appearances and dimensions. Users can interact with the learning media while participating in real-life situations in a virtual environment. The research methodology is described as follows.

Synthesis of the Conceptual Framework of the 3D-interactive Virtual Classroom

The 3D-interactive virtual classroom (3D-IVC) combines new technology with new teaching that allows students to interact directly with the virtual objects or surroundings. Unity is a popular program that is used to create and develop 3D virtual environments in which users can interact with virtual environments. Unity is considered suitable for the development of virtual learning media for learners. The researchers studied the relevant theories and the Unity software. They conducted an in-depth interview with learners to develop the conceptual framework for 3D-interactive virtual classrooms.

Design of the 3D-interactive Virtual Classroom

The researchers studied the structure and environment of a real classroom to design the layout of the 3D-interactive virtual classroom. The 3D-interactive virtual classroom was designed to make the learning process interesting and to attract the attention of learners. The contents allow learners to interact easily and the results to be readily followed up.

Development of the 3D-interactive Virtual Classroom

After the design stage, the 3D-interactive virtual classroom was developed using the Unity program. This provides appearance, dimension and simulated reality for users. Users interact for login, navigation, interaction, evaluation and log out consistent with Tzeng and Tien [12].

Results of the 3D-interactive Virtual Classroom

The 3D-interactive virtual classroom was tested using a sample of students from King Mongkut's University of Technology North Bangkok, Thailand (KMUTNB), by applying criteria from Kanasutra [13].

THE 3D-INTERACTIVE VIRTUAL CLASSROOM

Experts and students from KMUTNB used the 3D-interactive virtual classroom, and the development can be summarised as:

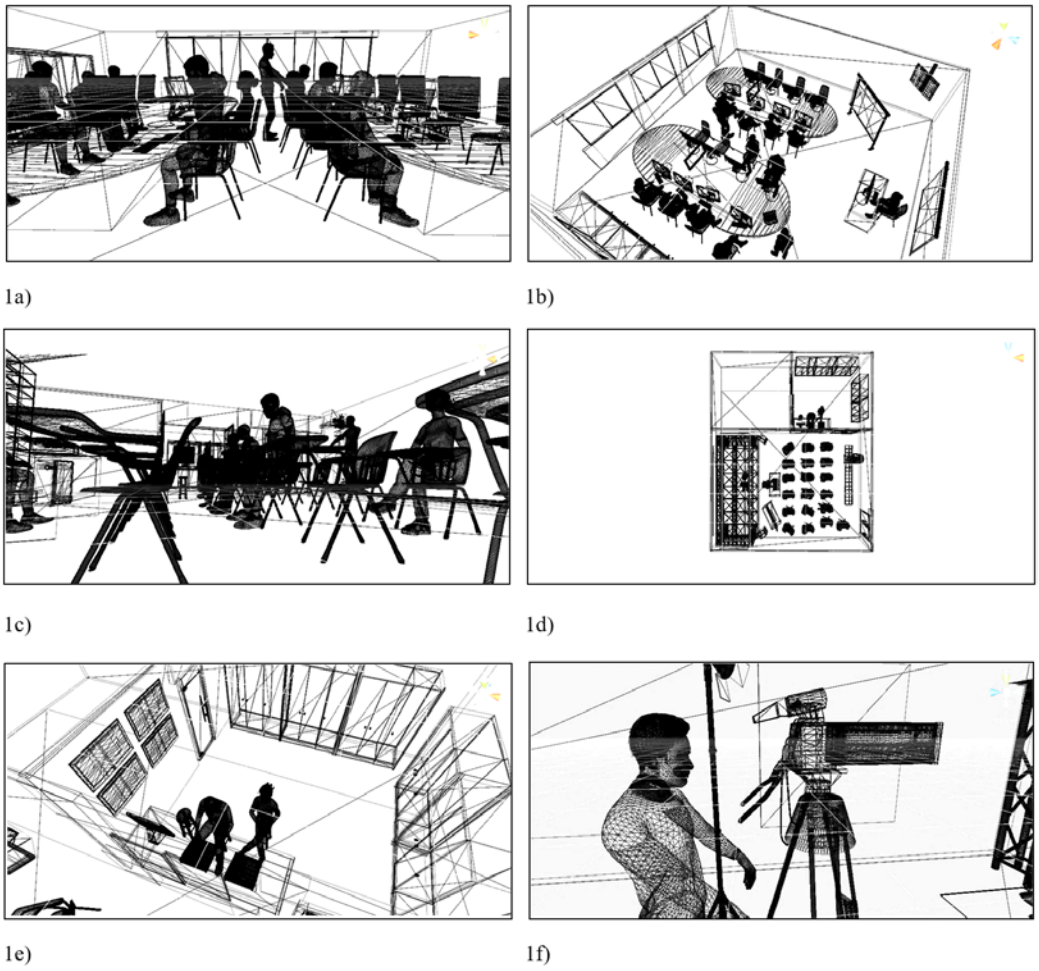
- Design of the 3D-interactive virtual classroom.
- Development of the 3D-interactive virtual classroom.
- Assessment of the 3D-interactive virtual classroom.

Design of the 3D-interactive Virtual Classroom

The interactive virtual classroom was designed with the structure and environment of a real classroom, i.e. the model was as similar as possible to a real classroom, as shown in Figure 1.

Development of the 3D-interactive Virtual Classroom

The development of the 3D-interactive virtual classroom was based on the design discussed above. The interactive virtual classroom reflected reality in appearance and dimensions. Interactions with various environments were simulated in the virtual classroom to encourage learning by participation and interaction as in a real classroom. This can be seen in Figure 2.

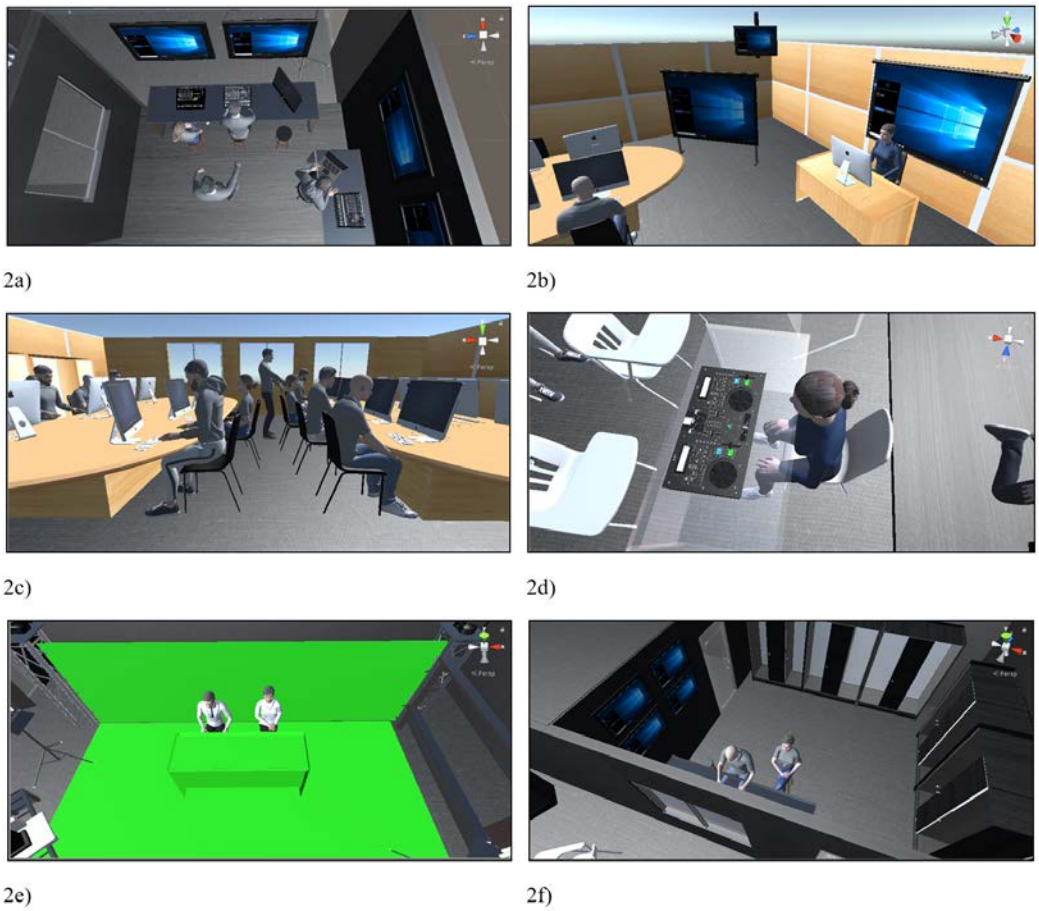


1a) 1b)

1c) 1d)

1e) 1f)

Figure 1: Design layout of the 3D-interactive virtual classroom.



2a) 2b)

2c) 2d)

2e) 2f)

Figure 2: Interactions in the 3D-interactive virtual classroom.

Assessment of the 3D-interactive Virtual Classroom

The 3D-interactive virtual classroom (3D-IVC) developed through applying the Unity software system supports the display of high-resolution images. The system was developed on a Windows PC platform. However, the switch to an Android operating system smartphone platform, as proposed for students, would result in an altered display. This is because the capability to support light and shade on a smartphone device is lower than that on a personal computer.

Appearance and Resolution of the 3D-interactive Virtual Classroom

Tests of the appearance and resolution of the system were divided into two parts:

1) The 3D-interactive virtual classroom running on a personal computer with the Windows operating system and running on a smartphone with the Android operating system.
2) The 3D-interactive virtual classroom running on smartphones with different versions of the Android operating system.

Table 1 shows results for the appearance and resolution of the 3D-interactive classroom on PCs and smartphones.

Table 1: Appearance and resolution for PCs and smartphones.

Device	Results (rating out of 10)				
	Light and shade	Resolution	Motion	Aliasing	FPS
Personal computer (Windows)	8/10	8/10	8/10	8/10	60
Smartphone (Android)	7/10	6/10	5/10	5/10	25

From Table 1, it is evident that the appearance and resolution of the 3D-interactive virtual classroom on a personal computer running the Windows operating system is superior to that on a smartphone running the Android operating system in all respects (light and shade, resolution, motion and aliasing).

Table 2: Appearance and resolution of different levels of the Android operating system.

Operating system version on smartphone	Results				
	Light and shade	Resolution	Motion	Aliasing	FPS
Android 6	3/10	2/10	3/10	2/10	15
Android 7	4/10	2/10	3/10	2/10	15
Android 7.1	4/10	5/10	5/10	4/10	15
Android 8	4/10	5/10	5/10	4/10	20
Android 8.1	5/10	5/10	5/10	5/10	20
Android 9	6/10	5/10	5/10	5/10	25
Android 9.1	7/10	6/10	5/10	5/10	25

Table 2 shows comparative results for the appearance and resolution of the 3D-interactive virtual classroom on smartphones that have different versions of the Android operating system. It is seen clearly that the Android version 9.1 has overall the best display among the tested versions of the Android operating system.

The usability of the 3D-interactive virtual classroom

In reference to the usability of the 3D-interactive virtual classroom, the results can be summarised in two parts:

1) Efficiency of the 3D-interactive virtual classroom.
2) Satisfaction with the use of the 3D-interactive virtual classroom.

The results are summarised in Table 3 and Table 4.

Table 3: Efficiency of the 3D-interactive virtual classroom.

Item evaluated	Results		Interpretation
	$\bar{X}$	SD	
1. Virtuality	4.30	0.57	High
2. Functions	4.30	0.66	High
3. Usability	4.15	0.67	High
4. Security system	4.00	0.00	High
5. Performance	4.30	0.57	High
6. Comprehensive coverage	4.15	0.37	High
Overall	4.20	0.53	High

The results of the evaluation in Table 3 were from experts specialised in designing and creating 3D virtual media, as well as scholars in the fields of the technology and innovation in virtual environments. The overall result is at a high level ($\overline{X}$ = 4.20, SD = 0.53).

Considering individual items: virtuality, functions and performance are followed by usability. It can be concluded that the 3D-interactive virtual classroom is of high efficiency and can be used to promote active learning among learners.

Table 4: Evaluation of satisfaction towards the use of the 3D-interactive virtual classroom.

Item	Results		Interpretation
	$\overline{X}$	SD	
1. Content	4.00	0.66	High
2. Images	4.25	0.60	High
3. Colours	4.30	0.59	High
4. Design of a virtual learning environment	4.62	0.56	Very high
5. Design of tools to promote learning	4.15	0.55	High
6. Suitability of the user interface design	4.28	0.61	High
7. Continuity of the use of 3D-interactive virtual classroom	4.12	0.58	High
8. Comprehensive coverage of the 3D-interactive virtual classroom	4.22	0.42	High
Overall	4.24	0.60	High

According to Table 4, the overall satisfaction of the use of the 3D-interactive virtual classroom is high: ($\overline{X}$ = 4.24, SD = 0.60). This can be interpreted as follows: the 3D-interactive virtual classroom can satisfy learners and promote their learning.

DISCUSSION AND CONCLUSIONS

The 3D-interactive virtual classroom (3D-IVC) is a simulation of a real classroom, including layout, dimensions and realistic virtual interactions. It was produced through Unity, a popular program used to create 3D virtual reality learning media. The interactions simulated in this virtual classroom encourage the learning processes and participation found in a real classroom.

The researchers designed and developed the structure and work processes in the 3D-interactive virtual classroom (3D-IVC) in accordance with the theory of Tzeng and Tien [12]. It was tested and used on a smartphone running the Android operating system. The results show that:

1) The Android version 9.1 had better display of the 3D-interactive virtual classroom than other versions of the Android operating system.

   It was better than or equal in all respects (light and shade, resolution, motion and aliasing).

2) The overall efficiency of the 3D-interactive virtual classroom was *high* as per results in Table 3 ($\overline{X}$ = 4.20, SD = 0.53).

   This is in line with the research of Syamsuddin, who stated that the virtual laboratory is useful for the development of learners' skills and knowledge [14].

3) The overall satisfaction with the use of the 3D-interactive virtual classroom was *high* as per results in Table 4 ($\overline{X}$ = 4.24, SD = 0.60).

   This is in agreement with the research of Ruiz et al, who opined that the combination of new technologies and innovations, such as augmented reality, is considered a new way to create a digital search environment that provides many advantages [15].

The 3D-interactive virtual classroom helps strengthen learners' imagination that can promote efficient learning.

This accords with the research of Chatwattana, who mentioned that interactive learning in an active learning environment enhances sharing knowledge and collaborative activities [16].

ACKNOWLEDGEMENTS

This research was funded by the College of Industrial Technology at King Mongkut's University of Technology North Bangkok (KMUTNB), Thailand.

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