Web-based virtual laboratory for the promotion of self-directed learning

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ABSTRACT: The 3D Web-based virtual laboratory learning media for the promotion of self-directed learning is a tool to help learners manage their active learning. Users feel as if they were working in a real physical place while interacting with the learning media. The structure of learning media involves five operational steps: 1) log in; 2) navigation; 3) interaction; 4) evaluation; and 5) log out. To design the virtual laboratory, the researchers studied the structure of a real laboratory, i.e. virtual channel KDTV, and used it as a model for the outline of the virtual laboratory and the learning media. The structure, similar to the real television station, was then created with a 3D program. The real television station and its virtual reality simulation consists of two sections, i.e. studio floor and studio control room.

Keywords: Web-based virtual laboratory, virtual laboratory learning media, self-directed learning

INTRODUCTION

Thailand 4.0 requires learning that can integrate knowledge in a creative and innovative way, to satisfy the needs of society. To produce education innovation of practical use, it is best to let learners act, think and develop skills based on real-life experiences. Therefore, instructors must develop environments and produce appropriate instructional material with advanced technology, such as cloud computing, a tool for instruction that enables learners to learn anytime, anywhere.

EDUCATION 4.0: PRESENT AND FUTURE INSTRUCTION

Education 4.0 is an education system that emphasises creativity and innovation to satisfy the needs of society. The system also focuses on the creation of skills and practices from experience, as well as co-operative learning, small group learning, and generating and integrating ideas to produce creative innovation [1]. To identify new concepts and integrate them to generate new knowledge, it is necessary to rely on the present learning environment. In the digital era, the search for knowledge requires the use of *cloud technology*.

In new generation education, instructors are required to place an emphasis on active learning, in which there must be challenging self-learning, creation of new knowledge, extension of existing knowledge and application of knowledge reflecting present real-life situations. Meanwhile, learners should be able to produce innovations that fulfil the demands of society. Instructors need to set up an environment to encourage learners in self-development and ability to apply critical thinking to solve problems on their own [2].

CREATION AND INFLUENCE OF ACTIVE LEARNERS

Essential to facilitating active learning is the creation of suitable surroundings. This allows a student to be an active creator of their own knowledge, but also to influence others [3]. Bonwell and Eison define active education as activities involving students in different activities and motivating them to think about these activities [4].

Competition is a characteristic of an active system of education affecting both the efficiency and the teaching method. Methodology is considered by many authors, and often illustrated graphically, e.g. knowledge pyramid, triangle and Dale's diagram - the *cone of learning* [5].

The closer the teaching method to real life, the more efficient it is. This suggests modelling real surroundings, conditions and situations, so a student can become an active participant in real activities or a simulation. For interactive simulations, a term inspired by IT is often used, i.e. applets: meaning small applications. Educational simulations date from the end of the 1960s.

VIRTUAL LABORATORY

A virtual laboratory is an instructional model that has become highly popular in Education 4.0 and among learners in the 21st Century. This instructional model uses technology to create an environment in which learners feel they are working by themselves. Moreover, it promotes instructional activities by encouraging learner participation and employs information technology to manage learning experiences by letting learners have an individual interaction. The model also includes simulation techniques to attract and inspire learners to be more active in learning and searching for information [6].

The virtual laboratory has the ability to remedy the problem of laboratory access in distance education, thus effectively spreading and extending laboratory availability in both time and space. Hence, it promises to become a key development trend in the practical teaching of future distance education [7].

SELF-DIRECTED LEARNING

Self-directed learning (SDL) is popular today, because information technology plays a vital role in learning among a new generation of learners who focus on active learning through media and information technology. One of the technologies that is popular and widely mentioned is cloud computing [8][9], in which a great number of resources are available in Internet networks, with no need for users to buy high-priced equipment. Thus, cloud computing has been applied to creating instructional activities for both instructors and learners in a convenient, assessable manner. This technology can create an alternative learning environment for learners.

Self-directed learning encourages learners to have active learning experiences enabling them to develop skills and the ability to plan their own learning. Hence, they implement active learning, search for learning resources and evaluate their own learning. The aim is to have learners help themselves as much as possible, from the beginning to the end of the learning process [10].

Awareness relates to students' understanding of the factors that contribute to SDL. Learning strategies require students to select specific strategies directly linked to SDL. Evaluation helps to reveal specific student attributes, with regard to how they monitor their individual learning [11].

According to the principles, concepts and theories, the researchers had the idea of designing and developing a Web-based virtual laboratory for the promotion of self-directed learning. This tool would promote active learning, create direct learning experiences by means of simulation, demonstrate how to use the equipment, and encourage learners' interaction and participation.

RESEARCH OBJECTIVES

- To analyse and synthesise the architectural design concepts of a Web-based virtual laboratory for the promotion of self-directed learning.
- To design the Web-based virtual laboratory.
- To develop the Web-based virtual laboratory.
- To apply the Web-based virtual laboratory for self-directed learning.
- To study results of the use of the Web-based virtual laboratory for the promotion of self-directed learning.

METHODS

The aim of the research was to design and develop a Web-based virtual laboratory for the promotion of self-directed learning. Thereby, the design and the development are based on a system approach and instructional system design that had the analyse, design, develop, implement, evaluate (ADDIE) model [12], including principles, concepts, and theories of co-operative learning. Thus, the researchers derived the methodology that is in accordance with the instructional system design of the ADDIE model. The research proceeded through the following phases:

Phase 1: To analyse and synthesise the architectural design concepts of the Web-based virtual laboratory for the promotion of self-directed learning.

The researchers studied relevant theories, the literature and other research to conduct an analysis and synthesis of architectural design concepts for the Web-based virtual laboratory. These included the theory of participatory learning, theory and elements of a virtual laboratory, theory of self-directed learning and principles of instructional system design. From this, the design structure of a Web-based virtual laboratory was derived, as shown in Figure 1,

including architectural design concepts of the Web-based virtual laboratory, which is further explained in detail below.

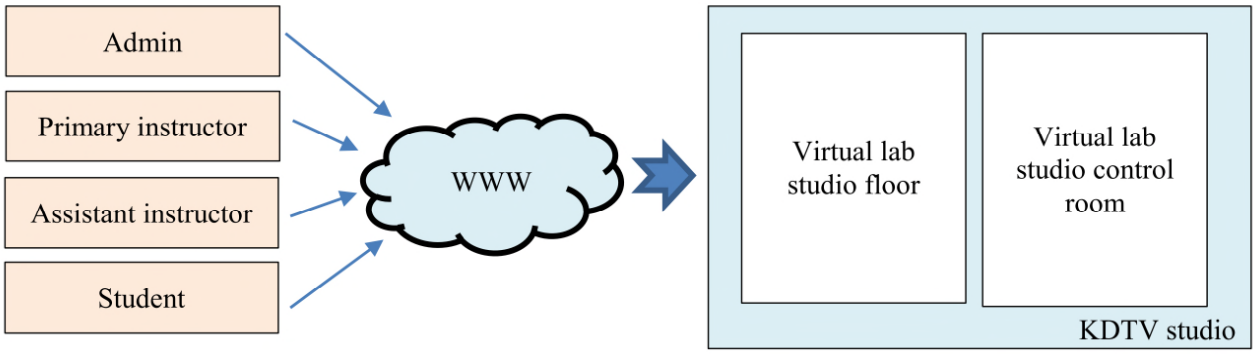


Figure 1: Structure of the Web-based virtual laboratory.

Phase 2: To design the Web-based virtual laboratory.

The researchers designed the outline of the Web-based virtual laboratory, to showcase the structure of an educational digital television station, which would be used as guidelines to develop learning media by means of a 3D program. According to the outline design of the virtual laboratory learning media, the researchers studied the structure of a real laboratory, i.e. KDTV, and used it as a model for the outline of learning media. The KDTV television station consists of two laboratories, i.e.

1) studio floor;
2) studio control room.

The researchers created this structure with a 3D program, so that the model would be similar to the real television station.

Phase 3: To develop the Web-based virtual laboratory.

The researchers applied the outline design concepts of the Web-based virtual laboratory as guidelines to develop Web-based virtual laboratory by means of a 3D program, so as to present the appearance of a real TV studio. This would enable users to feel as if they were working in the real place. The users can interact and use the learning media via the virtual reality simulation. The structure of the virtual laboratory learning media consists of five operational steps which is in compliance with the theory of Tzeng and Tien [14]:

1) log in;
2) navigation;
3) interaction;
4) evaluation;
5) log out.

Phase 4: To apply the Web-based virtual laboratory learning media for the promotion of self-directed learning.

This is the stage of testing and applying the Web-based virtual laboratory learning media to see whether the learning media should be acceptable or not [15]. The test consists of:

1) Alpha testing, which is the test of completeness of the learning media by the system developers. The test was conducted by repeatedly inputting simulated data into the system to identify defects, after which the media would be corrected and improved for further testing.

2) Beta testing, which is the test of completeness of the learning media by users. The sample group of users were the sophomore students in the Bachelor of Engineering Programme, College of Industrial Technology, King Mongkut's University of Technology North Bangkok.

Phase 5: To evaluate satisfaction with the Web-based virtual laboratory learning media.

This stage concerned the evaluation of satisfaction of the use of the Web-based virtual laboratory learning media by the sophomore students who enrolled in the subject: Television and Video Control System, Bachelor of Engineering Programme. The data analysis is based on satisfaction scores. The range and the translation of means and their translation into qualitative assessments are presented in Table 1.

Table 1: Mean score range and qualitative meaning [16].

Score range	Meaning
4.50 - 5.00	Highest satisfaction
3.50 - 4.49	High satisfaction
2.50 - 3.49	Moderate satisfaction
1.50 - 2.49	Low satisfaction
1.00 - 1.49	Very low satisfaction

ARCHITECTURAL DESIGN CONCEPTS OF THE WEB-BASED VIRTUAL LABORATORY LEARNING MEDIA

The architectural design concepts of the Web-based virtual laboratory were intended to comply with the principles of virtual laboratory design. The users are encouraged to interact with the virtual laboratory learning media as if they were learning in a real laboratory. The researchers applied participatory learning, which could provoke learners to interact with learning media and they promoted active learning, leading to enthusiasm and interest in participating in the instructional process. Also, self-directed learning was promoted and used to design the architecture of the Web-based virtual laboratory learning media, as shown in Figure 2.

Figure 2: Architecture of the Web-based virtual laboratory learning media.

Regarding Figure 2, the researchers designed and developed the architecture for the Web-based virtual laboratory learning media with the following two elements:

1) *User element:* users can access the system via a Web browser, and then register and log in to the system according to different access rights, such as administrator, primary instructor, assistant instructor or student. The system will show different registration menus depending on access rights.

2) *Application server element:* this is the server for running application software, which consists of two main sections.

- *Virtual laboratory studio floor:* this section includes *step 1*: present the contents and theories relevant to the preparation process of pre-production and production; *step 2*: present tips and tricks about the shooting of motion pictures, quality control of motion picture shooting and light control; *step 3*: after completing all lessons provided in instructional management, students can do tests to review their knowledge and understanding; *step 4*: students can practise production and lighting control via the simulation, in which the studio equipment of KDTV is virtually available, so that the users can learn of the operation process and principles of the equipment; and *step 5*: students can download the user manual of the studio equipment in KDTV.

- *Virtual laboratory studio control room:* this section includes *step 1*: present the contents and theories relevant to preparation process of post-production; *step 2*: present tips and tricks about editing with effect switching equipment, about editing television programmes with package software, about design, choices of microphone equipment, sound record and audio control with a sound mixer; *step 3*: after completing all lessons provided, students can do tests to review their knowledge and understanding; *step 4*: students can practise editing with the virtual effect switching equipment and mixer by referring to the operation and principles of real studio equipment in KDTV; and *step 5*: students can download the user manual of the studio equipment in KDTV.

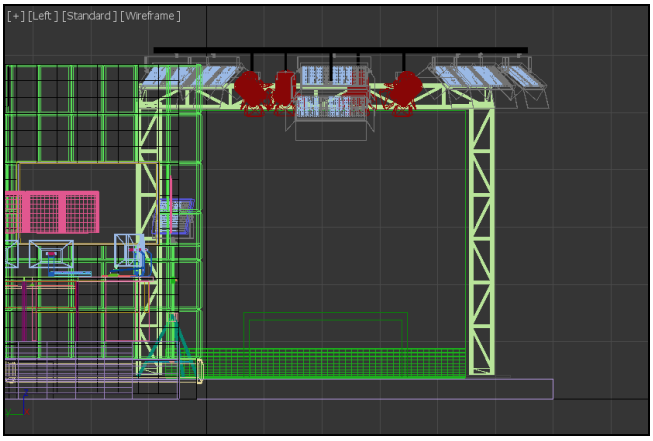
WEB-BASED VIRTUAL LABORATORY LEARNING MEDIA

The research results of design and development of the Web-based virtual laboratory are summarised thus:

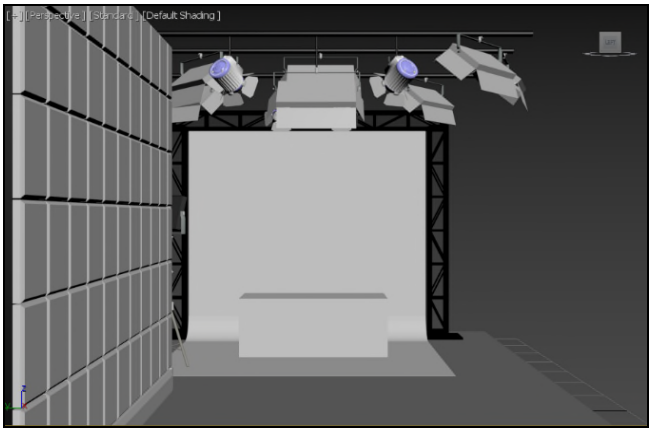
Section 1: Results of the outline design of the Web-based virtual laboratory learning media

The researchers designed the outline of the Web-based virtual laboratory learning media to showcase structure and proportion of the educational digital television station KDTV. This was to provide guidelines to develop learning media by means of a 3D program. The researchers studied the structure of a real laboratory, KDTV, and applied it as a model for the outline of learning media. The television station consists of two laboratories: 1) studio floor; and 2) studio control room.

Then the researchers created this structure with a 3D program to derive the structure and a model similar to the real television station, as shown in Figure 3 a), b) and c), and Figure 4.



a)



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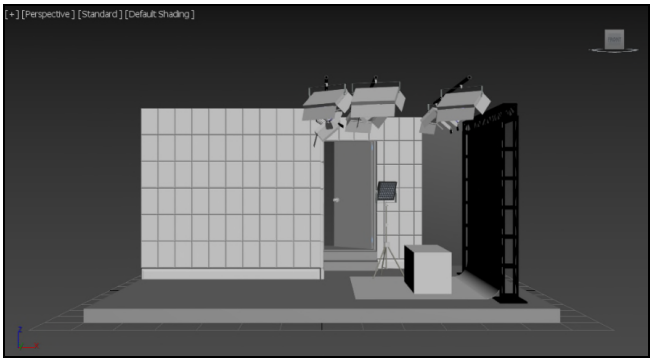
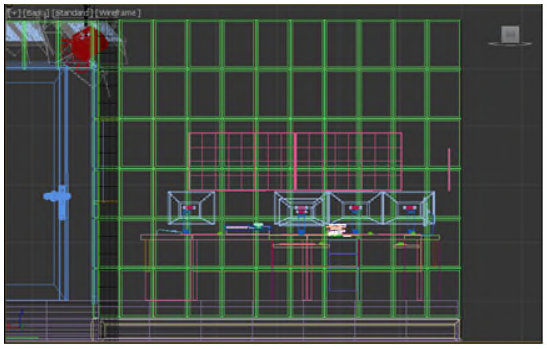
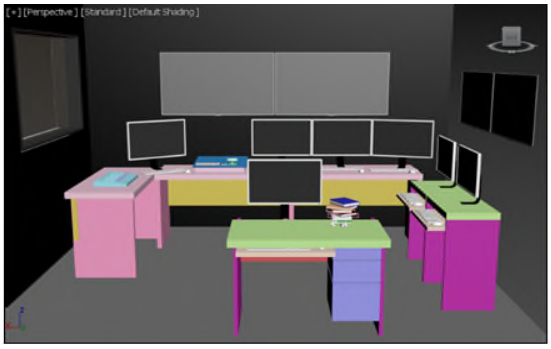


c)

Figure 3 a), b) and c): Web-based virtual laboratory (studio floor).





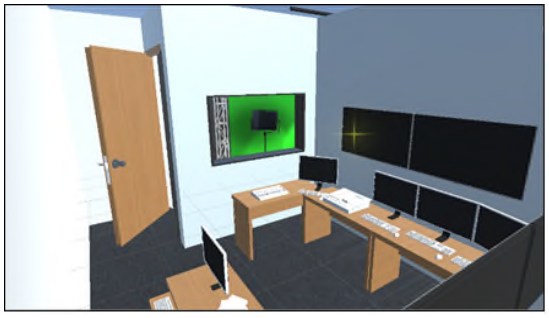
a) b)

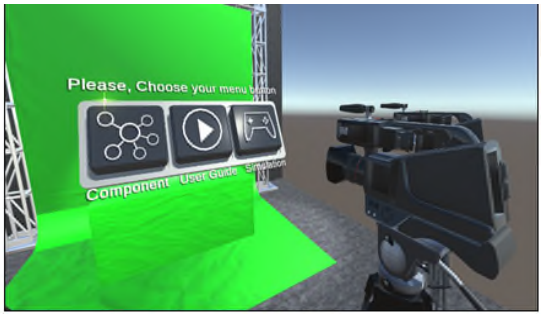
Figure 4 a) and b): Web-based virtual laboratory (studio control room).

Section 2: Results of the development of the Web-based virtual laboratory.

In this section, the researchers applied the outline design concepts of the Web-based virtual laboratory from Section 1 to develop the Web-based virtual laboratory by applying a 3D program. This presents the appearance, by applying virtual reality, which enables users to feel as if they were working in the real place. The users can interact and participate in the application and simulation of the learning media, as shown in Figure 5 a), b), c) and d).

a) b)





c) d)

Figure 5 a), b), c) and d): Use of the Web-based virtual laboratory learning media.

Section 3: Results of the application of the Web-based virtual laboratory learning media.

Results of the use of the Web-based virtual laboratory can be summarised into two parts, i.e. comparative results of student scores, and evaluation results of satisfaction with the Web-based virtual laboratory.

Comparative results of student scores. This is the comparison of test scores before and after learning using the learning media. The summary of the pre- and post-scores are illustrated in Table 2.

Table 2: Comparative results of pre- and post-learning scores.

Achievement score	N	Full score	$\bar{x}$	SD	*t*	Sig.
Pre-learning score	26	25	11.68	3.98	7.958	0.00*
Post-learning score	26	25	16.61	3.76		

* $p < 0.01$

Referring to Table 2, comparative results show that the post-learning score ($\bar{x}$=16.61, SD = 3.76) of the students was higher than the pre-learning score ($\bar{x}$= 11.68, SD = 3.98). Hence, the application of the learning media along with the instruction enabled the students to achieve a higher score.

Satisfaction with the Web-based Virtual Laboratory

The researchers conducted a two-part satisfaction evaluation, i.e. satisfaction with the quality of the Web-based virtual laboratory; and satisfaction with the efficiency of the Web-based virtual laboratory. Results are summarised in Table 3 and Table 4.

In reference to Table 3, the evaluation results of satisfaction with the quality of the Web-based virtual laboratory showed a highly positive result ($\bar{x}$= 4.58, SD = 0.69). It can be concluded that the Web-based virtual laboratory learning media satisfies and promotes learning among students.

Referring to Table 4, the results of the efficiency of the Web-based virtual laboratory shows that the suitability is at highest level ($\bar{x}$ = 4.59, SD = 0.68). It can be summarised that the Web-based virtual laboratory learning media is efficient and can promote learning among students

Table 3: Satisfaction with the quality of the Web-based virtual laboratory learning media.

Descriptions	Suitability		Level of suitability
	$\bar{x}$	SD	
Contents	4.73	0.60	highest
Images and languages	4.54	0.65	highest
Fonts and colours	4.38	0.70	high
Design of the Web-based virtual laboratory learning media	4.77	0.43	highest
Design of equipment to promote self-directed learning	4.65	0.49	highest
Design of activity in the Web-based virtual laboratory learning media	4.65	0.69	highest
Suitability of the user interface design	4.46	0.90	high
Continuity of the use of the Web-based virtual laboratory learning	4.42	0.90	high
Overall quality of the Web-based virtual laboratory learning media	4.58	0.70	highest
Overall average suitability	4.58	0.69	highest

Table 4: Satisfaction with the efficiency of the Web-based virtual laboratory.

Descriptions	Suitability		Level of suitability
	$\bar{x}$	SD	
Capability of learning media	4.69	0.62	highest
Functions	4.62	0.62	highest
Capability of usability	4.54	0.71	highest
Security system	4.62	0.64	highest
Performance	4.42	0.86	high
Overall efficiency of the Web-based virtual laboratory learning media	4.58	0.64	highest
Overall average suitability	4.59	0.68	highest

CONCLUSIONS

The Web-based virtual laboratory is a tool that the researchers have developed as learning media to promote active learning in addition to learning in class. It takes the form of a 3D Web-based virtual laboratory, which enables users to feel as if they were working in a real place. The users can interact with the learning media by simulation. The Web-based virtual laboratory is based on the educational digital television station KDTV. Within the television station are two laboratories: studio floor and studio control room. The learning media were designed to be compliant with the architecture of the Web-based virtual laboratory learning media, which consists of two main elements, i.e. user element and application server element, including two virtual laboratories, i.e. studio floor and studio control room.

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BIOGRAPHIES

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