The development of a simulation model of the international standard data center room environment with virtual reality technology (Virtual Reality)

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Abstract- The development of simulated environment for standardised data centre by virtual reality is in partially fulfilment of the requirement for master's degree in digital media technology. Data related to the development of simulated environment for standardised data centre by virtual reality are collected and studied. They consist of four necessary elements: 1) pretest; 2) a simulated environment for standardised data centre: contents aligned with ANSI/TIA-942 standard (telecommunication, electrical, architectural, and mechanical), virtual reality (3D pictures, video clips, and animation clips), and VR Glasses; 3) post-test; and 4) feedback (pass and not pass). Learners are able to randomly select interactive lessons for study without the alignment with ANSI/TIA-942 standard. The lessons in this data centre are interactive multimedia with real video clips from real sites. In case of failure, learners can return to the lessons and study again. This model is evaluated in terms of its appropriateness by nine experts. The results show that the contents for this data centre that is aligned with ANSI/TIA-942 standard is the most appropriate ($\bar{X}$= 4.70). Next, the model of the development of simulated environment for standardised data centre by virtual reality is the most appropriate ($\bar{X}$= 4.65) media design It is most appropriate (=4.87) The results of evaluating the suitability of the development of environment simulation media are the most appropriate (=4.89) The results of evaluating the suitability of environmental simulation are the most appropriate (=4.82) The results of finding efficiency An environment simulation system is a system that has been developed and is effective for use.

Keyword: **virtual reality, ANSI/TIA-942 standard, simulated environment, standardised data centre**.

I. INTRODUCTION

Producing hands-on graduates for graduate users in industry sectors concerns a numerous factors.The most important aspect should be a development of graduates with high competency and learning and practicing in real workplaces. A lack of standardised data centre is still problematic for courses or programs involving computer networks because of its high costs and unavailability for all campuses. This could lead to the incapable graduates.

Nowadays, virtual reality has been rapidly developed, and it has been applied for simulating data centres. This enables learners to have the opportunities to practice in the simulated environment where can be substituted the real sites. In addition, learners can be able to learn and get familiar with the elements and design standards for data centre construction.

From related studies, it showed that the virtual reality characteristics by 3D pictures is considered as the most effective teaching material. They can attract learners' attention and enhance learners' understanding [1][2][3]. Furthermore, the application of virtual reality for education can increase learners' attention and engagement [4][5][6][7]. Moreover, researches in tourism industry has brought virtual reality into their work for encouraging tourists to visit this virtual reality before experiencing the real spot of interests [8][9]. In the industrial sector, virtual reality has been used for empowering students' performance [10][11].

From the statements above, the simulated environment for standardised data center by virtual reality was constructed. The contents were aligned with Certified TIA-942 Design Consultant, designed by EPI, the first ANSI/TIA-942 CAB (Conformity Assessment Body) in the world. In addition, this simulated environment for standardised data centre was permitted from TIA for the correctness of information of this data centre based on ANSI/TIA-942 (TIA-942 Accreditation Scheme) [12][13][14].

II. RESEARCH OBJECTIVE

1. To study and analyse the elements of the development of simulated environment for standardised data centre by virtual reality.
2. To design the model of the development of simulated environment for standardised data centre by virtual reality.
3. To evaluate the appropriateness of the development of simulated environment for standardised data centre by virtual reality.

III. PROPOSED METHODOLOGY

This study was divided into three steps as follows:

1.Related documents and research articles about the simulated environment for standardised data centre by virtual reality were reviewed and analysed.

2.The development of simulated environment for standardised data centre by virtual reality was a logical design based on conceptual framework.

3.The development of simulated environment for standardised data centre by virtual reality is evaluated by five academicians and five experts from industrial sectors.

TABLE I. The criteria is divided into 5 levels.

Level	Meaning
0.00 - 1.49	the topic is the least appropriate
1.50 - 2.49	the topic is less appropriate
2.50 - 3.49	the topic is moderately appropriate
3.50 - 4.49	the topic is highly appropriate
4.50 - 5.00	the topic is the most appropriate

This evaluation form is validated by Index of Items Objective Congruence (IOC) from five experts. The interpretation is as follows:

+1 means a question is congruent with the objective.

0 means a question is congruent or not congruent with the objective

-1 means a question is not congruent with the objective

After that, scores obtained from the experts were calculated and interpreted as follows:

1) A question with IOC from 0.50 -1.00 is validate.

2) A question with IOC less than 0.50 is invalid, needs improvement

IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

1. Experimental results from this study which based on ANSI/TIA standard as a guideline for developing a simulated environment for standardised data centre by virtual reality are divided into four parts as follows:

1.1. Telecommunication involves networks in this data centre. It consists of four sub-elements:

1.1.1. Main Cross-Connect

1.1.2. Back bone Cabling

1.1.3. Horizontal Distribution

1.1.4. Equipment Distribution

1.2. Electrical supplies electric to the data centre. It consists of five sub-elements as follows:

1.2.1. Redundancy

1.2.2. Generators

1.2.3. MEDB

1.2.4. UPS

1.2.5. Grounding

1.3. Architectural is the design for this data centre. It contains four sub-elements as follows:

1.3.1. Floor Loading

1.3.2. Ceiling Load

1.3.3. Safety

1.4. Mechanical is the infrastructure involving with temperature control and data centre safety. It contains of three sub-elements as follows:

1.4.1. Air Condition

1.4.2. Fire Suppression

1.4.3. Water leak Detection

2. The result of the development of simulated environment for standardised data centre by virtual reality.

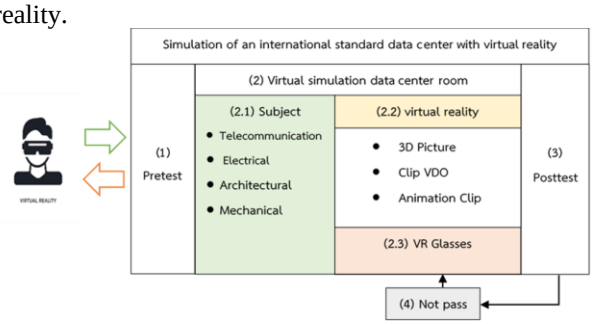

Figure 1. The model of the simulated environment for standardised data centre by virtual reality

The development of the simulated environment for standardised data centre by virtual reality consists of four elements as follows:

1) Pre-test

2) A simulation of environment for standardised data centre by virtual reality consists of three sub-elements as follows:

2.1) The contents based on ANSI/TIA-942 consist of:

2.1.1) Telecommunication

2.1.2) Electrical

2.2.3) Architectural

2.3.4) Mechanical

2.2) Virtual Reality

2.2.1) This multimedia is in form of 3D picture, video clip, and animation clip.

2.2.2) The media is the interactive lessons.

2.2.3) Students can choose any topics randomly, it is not necessary to be in sequence.

2.3) VR Glasses as the immersive system were used for communication by wearing on a head. It show pictures and sounds.

3) Posttest

4) Feedback (Pass, Not pass), in case of student fails the exam, they can study and review again.

V. RESULTS OF APPROPRIATENESS EVALUATION

1. Table II. shows the appropriateness evaluation of contents aligned with ANSI/TIA-942 standard for a design of the standardised data centre in a simulated environment for standardised data centre by virtual reality. This evaluation was assessed by nine experts.

Table II. shows the appropriateness evaluation of contents aligned with ANSI/TIA-942

Order	Items	Interpretation of appropriateness		
		$\bar{x}$	**SD.**	Meaning
1	Designing standardised data centre should be aligned with ANSI/TIA-942 standard	4.67	0.50	the most appropriate
2	The elements of the contents for standardised data centre consist of four sub-elements	4.69	0.46	the most appropriate
2.1	Telecommunication involves networks in this data centre. It consists of four sub-components:	4.61	0.49	the most appropriate
	1.1) Main Cross-Connect	4.78	0.44	the most appropriate
	1.2) Back bone Cabling	4.67	0.50	the most appropriate
	1.3) Horizontal Distribution	4.67	0.50	the most appropriate
	1.4) Equipment Distribution	4.33	0.50	highly appropriate
2.2	Electrical supplies electric to the data centre. It consists of five sub-elements as follows:	4.73	0.45	the most appropriate
	2.1) Redundancy	5.00	0.00	the most appropriate
	2.2) Generators	4.78	0.44	the most appropriate
	2.3) MEDB	4.56	0.53	the most appropriate
	2.4) UPS	4.89	0.33	the most appropriate
	2.5) Grounding	4.44	0.53	highly appropriate
2.3	Architectural is the design for this data centre. It contains four sub-components as follows:	4.63	0.49	the most appropriate
	3.1) Floor Loading	4.89	0.33	the most appropriate
	3.2) Ceiling Load	4.56	0.53	the most appropriate
	3.3) Safety	4.44	0.53	highly appropriate

Table II. Cont.

Order	Items	Interpretation of appropriateness		
		$\bar{x}$	SD.	Meaning
2.4	Mechanical is the infrastructure involving with temperature control and data centre safety. It contains of three sub-elements as follows:	4.78	0.42	the most appropriate
	4.1) Precision Air	5.00	0.00	the most appropriate
	4.2) Fire Suppression	5.00	0.00	the most appropriate
	4.3) Water leak Detection	4.33	0.50	highly appropriate
3	Utilizing virtual reality for simulated environment for standardised data centre	4.89	0.33	the most appropriate
4	overall	4.70	0.46	the most appropriate

Table III illustrates the appropriateness evaluation in terms of the development of simulated environment for standardised data centre via virtual reality with four academicians and five experts from industry sectors.

Table III. illustrates the appropriateness evaluation in terms of the development of simulated environment

Order	Items	Interpretation of appropriateness		
		$\bar{x}$	**SD.**	Meaning
1	The development of the simulated environment for standardised data centre by virtual reality consisted of four components as follows:	4.67	0.47	the most appropriate
1.1	Pretest	4.67	0.50	the most appropriate
1.2	A simulation of environment for standardised data centre by virtual reality consists of three sub-components as follows:	4.65	0.46	the most appropriate

Table III. Cont.

Order	Items	Interpretation of appropriateness		
		$\bar{x}$	**SD.**	Meaning
	1.2.1 The contents based on ANSI/TIA-942 consist of:	4.72	0.45	the most appropriate
	1) Telecommunication	4.89	0.33	the most appropriate
	2) Electrical	4.67	0.50	the most appropriate
	3) Architectural	4.56	0.53	the most appropriate
	4) Mechanical	4.78	0.44	the most appropriate
	1.2.2 Virtual Reality consists of three sub-elements as follows:	4.67	0.48	the most appropriate
	1) 3D picture, video clip, and animation clip	4.56	0.53	the most appropriate
	2) communication as immersive system	4.78	0.44	the most appropriate
	3) interactive lessons	4.67	0.50	the most appropriate
	1.2.3) VR Glasses	4.56	0.53	the most appropriate
1.3	Post-Test	4.67	0.50	the most appropriate
1.4	Feedback	4.56	0.53	the most appropriate
2	overall	4.65	0.47	the most appropriate

Table IV Results of evaluating the appropriateness of the media design for simulating the international standard data center room environment with virtual reality technology. by five experts consisting of three people from business establishments and two people from academic fields

Table IV. Results of evaluating the suitability of media design

Order	Items	Interpretation of appropriateness		
		$\bar{x}$	**SD.**	Meaning
1	General characteristics of the media	5.00	0.00	the most appropriate
	1.1 International standard data center environment simulation media Designed according to ANSI/TIA-942 standards.	5.00	0.00	the most appropriate
2	1.2 The method of contacting users is an Immersive System type.	5.00	0.00	the most appropriate
	Content according to ANSI/TIA-942 standards	4.86	0.35	the most appropriate
	2.1 Telecommunication	5.00	0.00	the most appropriate
	1) Backbone Cable	4.60	0.55	the most appropriate
	2) Horizontal Cable	4.60	0.55	the most appropriate
	2.2 Electrical	4.80	0.45	the most appropriate
	1) Generators	5.00	0.00	the most appropriate
	2) UPS	5.00	0.00	the most appropriate
	3) Electrical rails on the ceiling of the room	4.60	0.55	the most appropriate
	2.3 Architectural	4.80	0.45	the most appropriate
	1) Floor Loading	5.00	0.00	the most appropriate
	2) Security system (CCTV, access control)	4.60	.550	the most appropriate
	2.4 Mechanical	5.00	0.00	the most appropriate
	1) Precision Air	5.00	0.00	the most appropriate
	2) automatic fire extinguishing system	5.00	0.00	the most appropriate
	3) Water Leak	5.00	0.00	the most appropriate
	2.5 Displays 360-degree virtual images. The resolution of the virtual images is 1920x1080.	5.00	0.00	the most appropriate
3	Ease of use	4.80	0.42	the most appropriate
	3.1 Use media communication devices developed as glasses (VR Glasses)	5.00	0.00	the most appropriate
	3.2 Easy to access, not complicated	4.60	0.55	the most appropriate
4	Overall	4.87	0.34	the most appropriate

Table:V Results of evaluating the suitability of developing media to simulate an international

standard data center room environment with virtual reality technology. by fvei experts consisting of three people from business establishments and two people from academic fields

Table V. Results of evaluating the suitability of environment simulation media development.

Order	Items	Interpretation of appropriateness		
		$\bar{x}$	SD.	Meaning
1	side of correctness	4.72	0.46	the most appropriate
	1.1 Telecommunications system content	4.60	0.55	the most appropriate
	1.2 Electrical system contents	4.60	0.55	the most appropriate
	1.3 Architecture content (Architectural)	4.60	0.55	the most appropriate
	1.4 Mechanical system content	4.80	0.45	the most appropriate
	1.5 Accuracy of the simulation image of the international standard data center room environment according to ANSI/TIA-942 standards.	5.00	0.00	the most appropriate
2	aspects of user contact	5.00	0.00	the most appropriate
	2.1 Use media communication devices developed as glasses (VR Glasses)	5.00	0.00	the most appropriate
	2.2 Access to media that is easily developed and not complicated	5.00	0.00	the most appropriate
	2.3 Installing the program has easy-to-use steps.	5.00	0.00	the most appropriate
3	aspects of system usage	5.00	0.00	the most appropriate
	3.1 Displays 360-degree virtual images. The resolution of the virtual images is 1920x1080.	5.00	0.00	the most appropriate
	3.2 The speed of displaying data from the developed media is appropriate and consistent with the content according to ANSI/TIA-942 standards.	5.00	0.00	the most appropriate
	3.3 Media description text is consistent with content according to ANSI/TIA-942 standards.	5.00	0.00	the most appropriate
4	aspects of utilization	5.00	0.00	the most appropriate
	4.1 The developed media is useful in teaching and enhancing knowledge.	5.00	0.00	the most appropriate
	4.2 Overall appropriateness of media for use in learning to enhance student knowledge	5.00	0.00	the most appropriate
5	Overall	4.89	0.31	the most appropriate

Table VI Results of evaluating the suitability of simulating the international standard data center room environment with Virtual Reality (VR) technology developed by 5 experts, consisting of: 3 people from business establishments and 2 people from academic fields.

Table VI Results of evaluation of suitability for environment simulation

Order	Items	Interpretation of appropriateness		
		$\bar{x}$	SD.	Meaning
1	Simulation content of the international standard data center room environment according to ANSI/TIA-942 standards.	4.81	0.39	the most appropriate
	1.1 Telecommunications system (Telecommunication) has 4 subtopics.	4.80	0.45	the most appropriate
	1) Main Cross-Connect	4.80	0.45	the most appropriate
	2) Network main cable (Back bone Cabling)	4.80	0.45	the most appropriate
	3) Internal network connection cables (Horizontal Distribution)	4.60	0.55	the most appropriate
	4) Connection cable to equipment (Equipment Distribution)	4.60	0.55	the most appropriate
	1.2 Electrical system has 5 subtopics.	5.00	0.00	the most appropriate
	1) Power backup system (Redundancy)	5.00	0.00	the most appropriate
	2) Generators	5.00	0.00	the most appropriate
	3) Main electrical cabinet (MEDB)	4.80	0.45	the most appropriate
	4) Uninterruptible power supply (UPS)	5.00	0.00	the most appropriate
	5) Grounding (Grounding)	4.80	0.45	the most appropriate
	1.3 Architecture (Architectural) has 3 subtopics.	4.80	0.45	the most appropriate

	1) Room floor system (Floor Loading)	4.80	0.45	the most appropriate
	2) Ceiling Load Design	4.80	0.45	the most appropriate
	3) Security (Safety)	4.60	0.55	the most appropriate
2	Media development using virtual reality technology (Virtual Reality: VR)	4.90	0.31	the most appropriate
	2.1 Displays 360-degree virtual images. The resolution of the virtual images is 1920x1080.	4.80	0.45	the most appropriate
	2.2 Images used in media development include 3D Picture / Clip VDO/ Aanimation Clip.	5.00	0.00	the most appropriate
	2.3 The speed of displaying data from the developed media is appropriate and consistent with the content according to ANSI/TIA-942 standards.	4.80	0.45	the most appropriate
	2.4 Media description text is consistent with content according to ANSI/TIA-942 standards.	5.00	0.00	the most appropriate
3	Using the developed system	4.90	0.31	the most appropriate
	3.1 The method of contacting users is of the Immersive System type: which is a method of contacting individuals using head-worn devices to display images and sounds of the virtual world.	5.00	0.00	the most appropriate
	3.2 Use devices to interact with the virtual environment (VR Glasses)	5.00	0.00	the most appropriate
	3.3 Accessing the developed system Easy to use, not complicated	5.00	0.00	the most appropriate
	3.4 Overall suitability of the developed system	4.60	0.55	the most appropriate
4	Assessment of learning outcomes	4.60	0.52	the most appropriate
	4.1 Pre-study test	4.60	0.55	the most appropriate
	4.2 Post-test results	4.60	0.55	the most appropriate
5	Overall	4.82	0.38	the most appropriate

Table VII Results of evaluating the efficiency of the international standard data center room environment simulation system with virtual reality technology (Virtual Reality: VR).

Table VII Results of determining the efficiency of the environment simulation system.

Oder	Items	(N)	$\overline{x}$	E_1/E_2	Meaning
1	Before	10	8.7	80.83 /82.00	The developed system is efficient to use.
2	During	10	9.7		
3	After	10	16.4		

VI. DISCUSSION

Through research and development, a simulation model was created for the international standard data center room environment using virtual reality technology (Virtual Reality: VR) for education and learning, adhering to ANSI/TIA-942 standards of international standard data center room design.

Table 1 presents the results of an expert evaluation on the appropriateness of using ANSI/TIA-942 standards to design a central data center room of international standards. The average score falls within the very good criteria ($\overline{x}$ = 4.32, S.D. = 0.47).

Tables 2, 3, and 4 summarize the expert evaluations of media development, media design, and environment simulation with virtual reality technology. The average scores for each aspect fall within the very good criteria ($\overline{x}$ = 4.27, S.D. = 0.64; $\overline{x}$ = 4.87, S.D. = 0.34; and $\overline{x}$ = 4.89, S.D. = 0.31, respectively).

Table 5 presents the results of an expert evaluation on the appropriateness of environment simulation with virtual reality technology. The average score falls within the very good criteria ($\overline{x}$ = 4.82, S.D. = 0.38).

Table 6 demonstrates the performance results of the environment simulation system with virtual reality technology. The average scores for students before studying ($\overline{x}$=8.7), during studying ($\overline{x}$=9.7), and after studying ($\overline{x}$=16.4) indicate the effectiveness of the developed system for use.

VII. CONCLUSION

1. Virtual Reality Media (VR) for Studying and Learning about the Design of a Central Data Center Room of International Standards

A virtual reality (VR) simulation model has been developed for studying and learning about the design of a central data center room of international standards. This VR model is based on the ANSI/TIA-942 standards, which are the industry-wide guidelines for data center design.

2. Evaluation of ANSI/TIA-942 Standards

A panel of experts evaluated the appropriateness of using ANSI/TIA-942 standards in the design of an international standard data center room. The average score was in the very good criteria, indicating that these standards are appropriate for this purpose.

3. Evaluation of Media Development, Media Design, and Environment Simulation

Experts also evaluated the appropriateness of media development, media design, and environment simulation

for the VR model. The average scores for each aspect were within the very good criteria, indicating that these aspects of the model are well-designed and effective.

4. Efficiency of the Environment Simulation System

The efficiency of the environment simulation system was also evaluated. The results showed that the system is efficient to use and that it can effectively simulate the environment of a data center room.

Overall, the VR model is a valuable tool for studying and learning about the design of a central data center room of international standards. It is based on sound standards, is well-designed, and is effective in simulating the environment of a data center room.

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