International Journal of Advanced Research in Education and Society
e-ISSN: 2682-8138 | Vol. 3, No. 2, 90-96, 2021
http://myjms.mohe.gov.my/index.php/ijares

Virtual Reality Learning for Anatomical Environment: Respiratory and Digestive systems

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Accepted: 15 May 2021 | Published: 1 June 2021

Abstract: *Virtual Reality had become popular and important in the digital society. The VR technology provides interactive experiences to raise engagement and increase knowledge retention to many subjects, including medical study. This research presented the Virtual Reality (VR) anatomical case study for learning and teaching respiratory and digestive systems. The anatomical system was developed by using three-dimensional (3D) and game-engine software. The system was operated on a high-performance personal computer and presented to the participants through fully immersive VR gears: head- mounted display and sensory handheld remote controls. The effectiveness of the program system and usage satisfaction were examined by medical and VR experts, and thirty participants. The quality of system was evaluated by the experts and was rated at a very good level ($\overline{x}$ = 4.57). The operating system and satisfaction were highly rated ($\overline{x}$ = 4.51). The results indicated that the system developed in this study was practical and applicable to educational training and future research.*

Keywords: Virtual Reality, Anatomical Environment, Respiratory System, Digestive system

1. Introduction

In medical field, the understanding of anatomy is considered a fundamental of the further development (Moxham,B.J.&Plaisant,O,2007). Researchers have investigated and proposed various tools and approaches for teaching and learning in traditional medical courses, such as actual dissection, artificial models, and two-dimensional imaging pedagogies Brenner, (E., Maurer, H., Moriggl, B., & Pomaroli, A,2003). Virtual Reality (VR) is one of the recent technological integration (Falah, J., Harrison, D. K., Wood, B., & Evans, D,2012) that allows learners to explore and broaden their knowledge through 3D virtual simulation (S. F. AlFalah, DK. Harrison, D. K., V. Charissis, V., & Evans,D,2013.). The VR integration has attracted researchers to examine and develop VR software for many areas such as, medical education (Pensieri, C., & Pennacchini, M.,2014). Engineering (Itsarachaiyot, Y., Pochanakorn, R., Nillahoot, N., & Suthakorn. 2011)and general education (Nimnual R & Suksakulchai S., 2007). For anatomy learning, prior studies have focused on a single dimension of the contents, and VR Learning for Anatomical Environment: Respiratory and Digestive systems never been explored. The current study, hence, aimed to develop VR Learning for Anatomical Environment for Thai medical learners. The software was developed and illustrated though a fully immersive VR equipment. The VR application in this study provides medical learners and educators an alternative content in exploring anatomical knowledge with interactive experience regardless of location and resource availability.

2. Literature Review

Virtual Reality integration enables learners to explore anatomical information in a more thorough manner. VR, in addition, is cost- effective and reduces diverse disposable and limited resources, such as real-organ usage and pictorial presentation. Researchers have examined and proposed VR anatomical development to augment traditional learning and teaching anatomy (Richardson, A., Hazzard, M., Challman, S. D., Morgenstein, A. M., & Brueckner, J. K., 2011). For example, the 3D visualization system, Second Life, to assist anatomical learners to explore anatomy contents in additional to their traditional materials, the online virtual laboratory to offer a wide range of anatomical information to the learners, and the VR anatomy system simulating the heart structure (Falah, J., Khan, S., Alfalah, T., Alfalah, S. F. M., Chan, W., Harrison, D. K., & Charissis, V,. 2014). The software developed in this study aimed to be a supplementary teaching tool for teaching anatomy and to fill the gap in the existing VR literature and development. The present study aimed to design and develop the virtual reality system for anatomical learning environment for Thai undergraduate medical students.

3. Methodology

Participants

In this research, 30 participants were recruited from Biomedical Media Technology curriculum, School of Architecture and Design, King Mongkut's University of Technology Thonburi, Bangkok, Thailand by using a purposive sampling method. The participants were attending anatomy class in their second year. Two experts in medicine and anatomy and three experts in media and virtual reality (VR) were invited to evaluate the quality of the research tool

Material

Two researching tools were used in this study: an experimental software and questionnaires. The questionnaires were divided into two categories, a software evaluation evaluated by the experts, and a satisfaction evaluation.

A software evaluation questionnaire

The software evaluation questionnaire was developed and validated by conducting index of item objective congruence (IOC). This questionnaire was used to evaluate the quality of the software. The media and anatomical content aspects of the software were evaluated in the questionnaire. The media was composed of graphics, animation, sounds, user experience and user Interface (UX/UI). The quality evaluation of each aspect was rated on a five- point Likert-scale, ranging from 1 (very poor) to 5 (very good). The developed questionnaire was, then, used to assess the quality of the software by three experts in media and two experts in medicine and anatomy. The assessment result demonstrated that both media aspects and anatomical contents of the software were rated at a good level (>4.00).

A satisfaction evaluation questionnaire

The satisfaction form was used to assess satisfaction after participating the software experiment. The form was developed and validated by conducting index of item objective congruence (IOC). The form consisted of twenty items. Each item was rated on a five- point Likert-scale, ranging from 1 (very dissatisfied) to 5 (very satisfied).

Pre-test and post-test materials

The testing material consisted of twenty multiple-choice items. The test was designed to evaluate the knowledge of the participants after using the software. The material was qualitatively evaluated by conducting IOC, quality reliability (KR-20), and Difficulty Factor (DF). The IOC was for testing a validity of the test. This process was performed by six experts. The items which had an IOC value between 0.05-1.00 were selected for the test.

The quality reliability was performed by using KR-20 formula. The KR evaluation was done with thirty samples, who had studied the anatomy course (third-year). After that, the test was evaluated for DF. The items which had a value between 0.20 - 0.80 were selected to use for the pre-test and post-test.

Virtual Reality (VR) software development

The software was developed by using Auto Desk Maya version 2018 and Unity 3D game engine. The contents used in the VR software was obtained by reviewing literature and consulting experts in VR and medicine clinics. After that, the 3D model was created according to the complied knowledge and contents. The 3D models were composed of Respiratory and Digestive systems that shown in Figure 1 and 2.

Figure 1: Shown development of VR anatomy by using Unity 3D

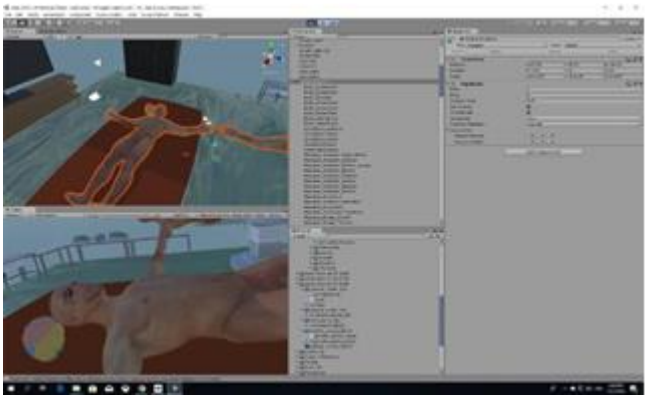

Figure 2: Shown anatomical model

UX and UI Design

For user experience (UX), user journey when using VR for learning and how user to interact with the models and objects in VR system were designed based on functional requirements. For user interface (UI), the design focused on realistic and aesthetics.

Create draft design of each screen in the VR system based on the UI design.

Link screens and images to show how user can interact with the VR system and how model and information to be displayed based on the UX design.

Design and create backgrounds and scenes in 3D, then test all the components in VR system.

UI Types in this system
Non-diegetic: an UI type for showing various information that will pop up on the screen, for example, scoring blood vessels, character names and basic character information.

Spatial: an UI type for showing the scene around the model or object which can be displayed in a 360-degree view or character's point of view.

Diegetic: an UI for showing details inside Spatial UI for increased visual realism and sophistication, for example, television or computer screens, and holographic images

Meta: an UI for showing special features, for example, changing colors when an object was changed, blood displayed on screen when an organ was damaged, or blurred image when showing specific area or image.

Figure 3: Shown user interface design in VR

Hardware

In this research we used a head mounted display, called Oculus Rift, that is a wearable human head device using an OLED screen with a resolution of 1080x1200, with a frequency of 90 Hz and a wider refresh than scanned lines. The Oculus Rift can display an image for 2 milliseconds for each frame, called Low Tracking display format. The refresh rate is at a high level and can be refreshed at an extensive level. And with low tracking format, participant will not receive bad experience from blurriness that can occur on the screen. The Oculus Rift uses a lens that allows a wide field of view. Lens adjustment for the operation can be adjusted by pressing on the bottom of the machine. The Oculus Rift can also let participants wearing glasses able to use without problems as well as participants with different face shapes will enable to be used as well. The headphones have realistic sound as if we were in that situation. This technology was developed with permission from Real Space 3D Audio by Visionics. The Oculus Rift has full rotation and position tracking. This tracking is performed by the Oculus's Constellation tracking system and has a microscale accuracy that shown in figure 4.

Figure 4: Shown a participant using an Oculus Rift

Data collection procedures

Before using the developed software, the participants were asked to do the pre-test to assess their prior knowledge in anatomy. The participants, then, used the software to learn about anatomy. The participants could select contents they were interested in and explored. The learning duration was 1 hour per week. The experimental period lasted for 3 weeks. At the end of the third week, the participants were asked to do the post- test. The scores of the pre-test and post-test were statistically analyzed. The developed software was piloted with one of the participants to test the system. The interactive visualization of the anatomical models in the system was illustrated in 3D. The software was operated and presented through a set VR gears: 1) Head mounted display (Oculus rift), a virtual reality headset developed and manufactured by Oculus VR and 2) Oculus Touch controllers for touching parts of anatomy in the VR

4. Results

The analytic results demonstrated that participants had gained more knowledge after using the software. The results revealed that the developed VR software was effective and could be used in teaching and learning anatomy. The evaluative results by the experts showed that the quality of the software was rated at a very good level (4.57). For the usage satisfaction, the software was rated at a very-satisfied level (4.51) (Table 1 and 2).

Table 1: Software evaluation results (evaluated by 5 experts)

Topics	Means ($\bar{x}$)	SD
Graphic & Animation	4.56	0.53
Content illustration and presentation	4.58	0.64
Reality of illustrations	4.60	0.64
Harmony of illustrations and contents	4.55	0.52
Ease of usage	4.57	0.64
Total	4.57	0.59

Table 2: Satisfaction evaluation results by 30 participants

Topic	Mean	SD	Score
1. Learning Behavior			
- understanding of anatomy	4.50	0.52	Excellent
- Easy to understanding in anatomy content	4.25	0.54	Good
Mean	4.38	0.53	Good
2. Design			
-The model is realistic	4.56	0.68	Excellent
- Indoor environment	4.60	0.00	Excellent
Mean	4.58	0.64	Excellent
3 Interactive			
- The response of the rotation of various organs Is smooth and realistic	4.50	0.70	Excellent
- Easy to use motion control	4.66	0.59	Excellent
Mean	4.58	0.64	good
Total	4.51	0.62	Excellent

These results suggested that Virtual Reality Learning for Anatomical Environment: Respiratory and Digestive systems can be used in teaching and learning anatomy

5. Conclusion

The VR system developed in this study was a prototype in learning anatomy vocabulary and descriptions. This software could provide more understanding in anatomy to students in medical fields and individuals who are interested in the subject. Moreover, the developed software can pave the way and serve as a guideline in developing VR in medicine, such as VR surgical training and VR symptom diagnosis, and related disciplines. The system will also help diminish limitations in terms of disposable resources in theoretical and practical studies

Acknowledgement

This work is supported by Media Arts and Technology, School of Architecture and Design, King Mongkut's University of Technology Thonburi, Bangkok, Thailand

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