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Virtual Reality for Anatomical Learning

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Abstract: *Virtual Reality has become popularly pervasive among people in the digital society. The prevalent availability and usefulness of VR lend facilitations to diverse disciplines, especially medicine. The current study developed a Virtual Reality (VR) anatomical vocabulary learning program. The anatomical contents were developed by using three-dimensional (3D) and game-engine softwares. The developed program was operated on a high-performance personal computer and presented to the participants through fully immersive VR gears: head-mounted display and sensory hand-held remote controls. The effectiveness of the program system and usage satisfaction were examined by medical and VR experts, and thirty health practitioners. The system program was assessed to be at a highest level ($\overline{x}$ = 4.65). The operating system and satisfaction were highly rated ($\overline{x}$ = 4.57). The results indicated that the program development in the study is practical and applicable to educational training and future research.*

Keywords: Virtual Reality, Anatomical Learning

1. Introduction

Technological advancement has transformed how educational knowledge is presented and delivered (Falah, Khan, Alfalah, Alfalah, Chan, Harrison, & Charissis, 2014). In medical field, The understanding of anatomy is considered fundamental in order to further development (Moxham & Plaisant, 2007). Research has investigated and proposed various tools and approaches to traditional teaching and learning in medicine, such as actual dissection, artificial models, and two-dimensional imaging pedagogies (Brenner, Maurer, Moriggl, Pomaroli, 2003; Lufler, Zumwalt, Romney, Hoagland, 2010; Pabst, 2009). Computer-based learning (CBL) has been recently introduced and adopted to facilitate medical education, especially anatomical learning (Azer & Eizenberg, 2007; Tam, Hart, Williams, Holland, Heylings, & Leinster, 2010). Three-dimensional (3D) contents have been constantly developed to optimize the learning (Tam et al., 2010). Virtual Reality (VR) is one of the recent technological integration (Fallah, Harrison, Wood, & Evans, 2012). VR allows learners to explore and broaden their knowledge through 3D virtual simulation (AlFalah, Harrison, Charissis, & Evans, 2013; Craig, Sherman, & Will, 2009; Oestergaard, Bjerrum, Maagaard, Winkel, Larsen, Ringsted, & Soerensen, 2012). The VR integration has attracted researchers to examine and develop VR softwares for medical education, such as anatomy (Izard, Méndez, & Palomera, 2017), surgery (Pensieri & Pennacchini, 2014), and therapy (Alahmari, Sparto, Marchetti, Redfem, Furman, & Whitney, 2014). Prior studies have focused on a single dimension of the integrated contents, particularly anatomical learning (Fallah et al., 2014; Izard et al., 2017; Maresky, Oikonomou, Ali, Pakkal, & Ballyk, 2018; . Marks, White, & Singh, 2017). In Thailand, VR have been applied to certain educational development, such as engineering and general education (Itsarachaiyot, Pochanakorn, Nillahoot, & Suthakorn, 2011; Lertkulvanich, Buranajant, & Sombunsukho, 2010; Nimnual & Suksakulchai, 2007). VR anatomical vocabulary for teaching and learning has never been explored. The current study, hence, aims to develop VR anatomical vocabulary for Thai medical learners.

The software is developed and illustrated though a fully immersive VR gear. The developed VR application provides medical learners and educators a novel alternative in exploring anatomical knowledge regardless chronological, positional, and resource concerns.

2. Literature Review

The development of technology has extended educational provisions in various disciplines, including medicines. Anatomical knowledge is regarded as an essential foundation for developing expertise in specific medical areas (Turney, 2007). 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 in order to augment traditional learning and teaching anatomy (Fyfe et al., 2013; McNulty et al., 2009; Richardson, Hazzard, Challman, Morgenstein, Brueckner, 2011; Rizzolo and Stewart, 2006). Richardson et al. (2011) developed a 3D visualization system, Second Life, to assist anatomical exploration for university students in addition to their anatomy learning. The online virtual laboratory offered a wide range of anatomical information to the users. Fallah et al. (2014) designed and developed VR anatomy system for anatomy teaching. A heart structure and information were transformed and simulated in the system. Izard et al. (2017) developed a VR software compatible with portable goggles. The human skull was presented in the software.

The development aimed to be a supplementary teaching tool for teaching anatomy. Through the review of VR literature in medical education, the software development and contents have been confined to a single anatomical part. In order to fill the void in the existing VR literature and development, the present study aims to design and developed anatomical vocabulary VR for Thai undergraduate medical students.

3. Methodology

3.1 Participants

In this study, twenty participants were recruited from Bio Medical Technology from King Mongkut's University of Technology Thonburi through a purposive sampling methods. 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 a quality of the research tool.

Figure 1: VR anatomy utilization by the participant

3.2 Material and Methodology

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

Figure 2: VR anatomy system testing by the sample group

3.2.1 A Software Evaluation Questionnaire

The evaluation tool 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 is composed of graphics, animation, sounds, and User Experience and User Interface (UX/UI). The quality evaluation of each aspect is 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).

3.2.2 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).

3.2.3 Pre- and Post-Tests 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. 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- and post-tests.

3.2.4 Virtual Reality (VR) Software Development

The software was developed by using Auto Desk Maya program version 2018 and Unity 3D program. The contents used in the VR software was obtained by reviewing literature and consulting experts in VR and medicine and clinics. After that, the 3D model was created according to the complied knowledge and contents. The 3D models were composed of all parts of a human body

3.3 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 were allowed to select contents they were interest-ed in and explored. The duration of the learning from the software was one 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- and post-tests were statistically analyzed for an achievement result after using the software. The developed software was piloted with one of the participants to test the system. The visualization of the anatomical models in the system was illustrated in 3D and could be interacted with. The software was operated and presented through a set VR gears: Head mounted display (Oculus rift) - a virtual reality headset developed and manufactured by Oculus VR - and Oculus Touch controllers - for touching parts of anatomy in the virtual word

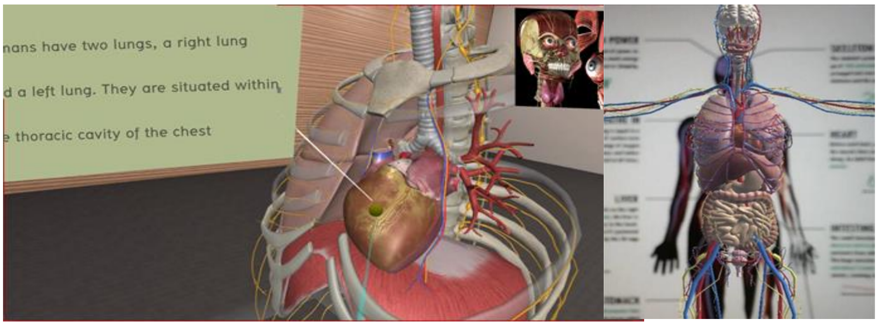

Figure 3: Anatomy illustration in the VR software

4. Result

The analytic results demonstrated that participants had improvement after using the software, as shown in Figures 5.

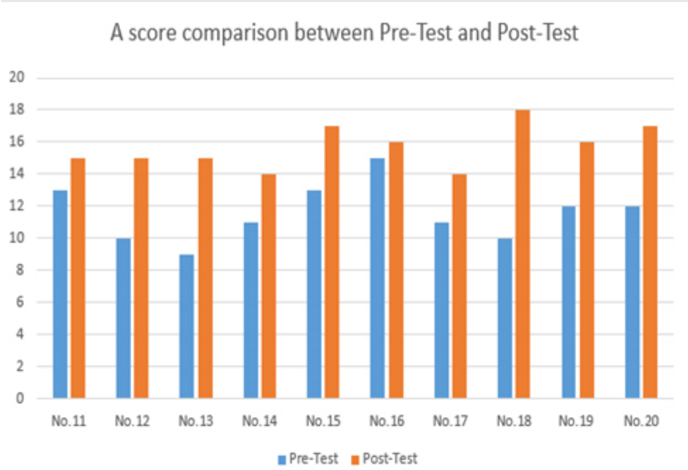

Figure 5: Pre- and post-test score comparison

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 (4.65). For the usage satisfaction, the software was rated at a very-satisfied level (4.57) (Table 2).

Table 2: Statistic results of usage satisfaction

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

These results suggest that VR anatomy software can be used in learning and developing VR for education. In conclusion, the developed VR software for anatomy 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 developed VR software will also help diminish limitations in terms of disposable resources in theoretical and practical studies.

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