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Complementary Learning: When Virtual Reality Meets Anthropology

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Abstract: The foundation of anthropology learning lies in the knowledge of the human skeletal system. As human skeletons have become increasingly difficult to obtain, complementary anatomy learning tools are needed. One innovation that can enhance students' understanding of anatomy is the use of three-dimensional technology through virtual reality (VR). The use of VR in learning is expected to help students study anatomical structures in greater detail compared to relying solely on atlases or textbooks. This study employed a cross-sectional design involving 22 first-semester medical students from the Faculty of Medicine and Health Sciences, University of Mataram (FKIK Unram), focusing on osteology anatomy. Students were given the opportunity to study the skeletal system using the Oculus Quest 3 virtual reality device. The skeletal framework within the VR application was specifically designed for medical students, featuring Latin bone labels and adjusted to the undergraduate competency level. The study also evaluated students' expectations, which were generally categorized as high, with a mean score of 4.18. Only one item was categorized as moderate, with a mean score of 4.00, likely due to the short duration of VR exposure. Overall, students demonstrated high acceptance and expectations toward the use of virtual reality as a complementary tool in anatomy learning.

Keywords: Anatomy; Complementary; Learning; Virtual reality

Introduction

At the higher education level, the learning process becomes increasingly specialized, as seen in medical faculties where students study anatomy focusing on the functions and structures of the human body (Sukma & Purwanti, 2020). One of the anatomical topics that concentrates on specific body structures is forensic anthropology. The foundation of forensic anthropology lies in the knowledge of skeletal biology and other subjects related to it (Putra, 2017, in Harahap et al., 2023).

Traditionally, anatomy learning has relied on textbooks or atlases and practical sessions using cadavers. Over the past few decades, and especially during the COVID-19 pandemic, there has been a significant transformation in anatomy education. During this period, anatomy learning underwent changes in terms of virtual platforms, innovative technological explorations, pedagogical approaches, and assessment methods (Singal, 2022). One of the emerging technologies in this field is **virtual reality**.

The use of virtual reality (VR) technology in education and training has attracted widespread attention due to its ability to create virtual environments where learners are guided to accomplish specific tasks and acquire new skills (Norris, Spicer, & Byrd, 2019). When VR is applied in medical education, it provides a safe environment in which students can gain enjoyable, engaging, interactive, and cost-effective learning experiences by eliminating potential risks (de Ribaupierre et al., 2014). The diversity of research on virtual reality highlights the importance of further studies to enhance knowledge and understanding in this field.

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Method

This study employed an experimental design using the post-test only control group method. Evaluation of the research groups was conducted after the application of the virtual reality intervention. Research procedures:

a. Development of the Virtual Reality Application
In this stage, several human bones were created in the form of virtual reality models. The development process involved technology experts and software developers, who collaborated to design the application according to user needs and anatomical learning objectives.

b. Respondent Testing
All respondents received an initial tutorial on how to use the virtual reality application. After the orientation, participants began exploring the bone models within the virtual reality environment.

c. Evaluation of the Virtual Reality Application and Reporting
The instrument used in this study was the Oculus Quest 3 virtual reality headset. The skeletal anatomy program utilized in this research had been previously developed. To assess students' expectations after using the virtual reality application, an evaluation was conducted using a questionnaire distributed to respondents who met the inclusion criteria.
The questionnaire was adapted and modified from the Unified Theory of Acceptance and Use of Technology (UTAUT) Model, consisting of 13 statement items or indicators covering two main variables: performance expectancy and effort expectancy.

Result and Discussion

The development process of this virtual reality application utilized a relatively simple interface and menu design. The explanation regarding navigation and the use of features within this application is described in the following points:

User Controller

In this application, users in the virtual environment can move and navigate using their VR controllers. The main navigation button used by the user is the *thumbstick*—commonly referred to as the *analog* by gamers—located on the right-hand VR controller.

Grab Object

The *Grab Object* feature allows users to interact with virtual elements by holding and manipulating bone objects within the application. The button used to perform this grabbing action is the *grip button* on the VR controller. Each controller can hold only one object at a time, allowing a maximum of two interactable objects when using both the left and right controllers simultaneously.

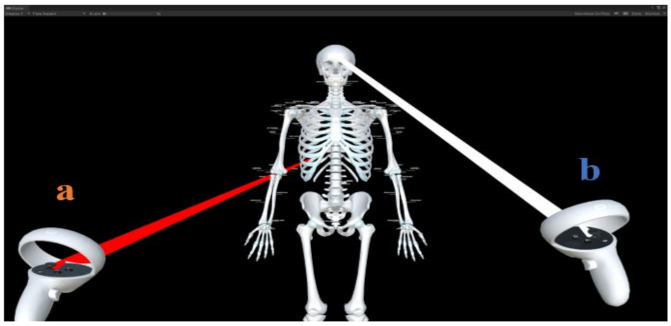

Figure 1. Interaction process with the anatomical bone object;
a) The red line indicates that the left controller is not yet able to interact with the bone object;
b) The white line indicates that the right controller is able to interact with the bone object.

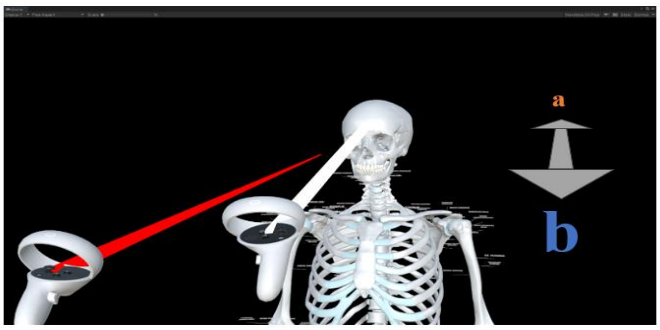

Figure 2. Process of controlling the bone object distance while in the Grab state;
a) When the analog is moved upward, the object moves farther away;
b) When the analog is moved downward, the object moves closer.

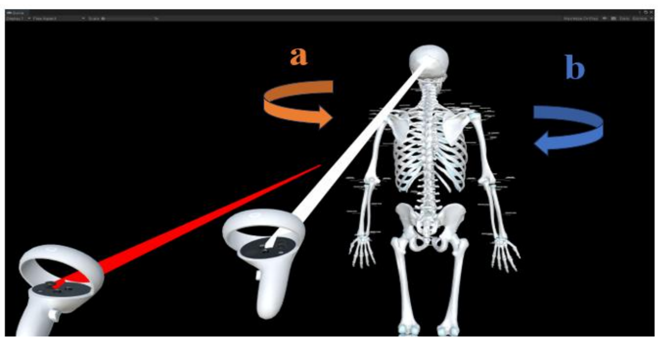

Figure 3. Control process of bone object rotation during the Grab interaction;
a) Moving the analog stick to the right causes the object to rotate clockwise;
b) Moving the analog stick to the left causes the object to rotate counterclockwise.

Zoom Object

The *Zoom Object* feature allows the user to enlarge the bone object within the application. The button used to perform the zoom function is the **Trigger** button on the VR controller. Similar to the *Grab Object* feature, only one object can be zoomed in per controller (a total of two objects for the left and right controllers).

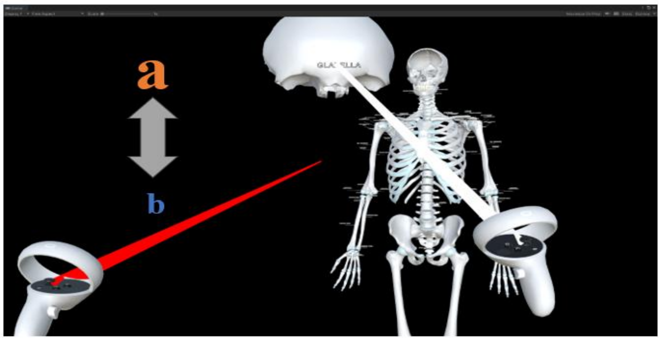

Figure 4. Bone object during the Zoom interaction; a) Moving the analog stick upward enlarges the object scale; b) Moving the analog stick downward reduces the object scale.

Reset Object

The *Reset Object* feature is an instruction that can be used to return the bone object to its original state. If the bone object has been moved, rotated, scaled, or separated, it can be restored to its initial position, rotation, size, and structure by pressing the **A** button located on the right VR controller.

In the next phase, this application was tested on respondents who were active students of the Medical Education Study Program, Faculty of Medicine and Health Sciences, University of Mataram, consisting of 5 males and 17 females. Respondents were given a questionnaire after experiencing skeletal anatomy learning through the virtual reality application. The questionnaire consisted of two variables: performance expectancy and effort expectancy. The performance expectancy variable included eight statements. The respondents' results are presented in Table 1. According to Table 1, the respondents' mean performance expectancy score was 4.18, which indicates a high expectancy level (X ≥ 3.67) regarding learning through virtual reality.

With regard to performance expectancy, Table 1 indicates that the majority of respondents agreed with the statement "Using the virtual reality application is beneficial for learning." This result aligns with the findings of Zhao et al. (2020), who reported that students generally found learning with virtual reality more engaging than conventional or two-dimensional learning approaches.

Regarding the effort expectancy variable, it consisted of five statements. The respondents' mean scores are shown in Table 2.

Tabel 1. Respondents' Performance Expectancy

Item	Statements	Mean	SD
P1	Virtual Reality helps me learn faster	4.00	0.87
P2	Virtual Reality application improves my performance in learning	4.05	0.89
P3	Virtual Reality application increases my productivity in learning	4.14	0.94
P4	Virtual Reality application enhances my motivation to study	4.45	0.86
P5	Virtual Reality application makes it easier for me to complete exercises or tasks	3.77	0.97
P6	Virtual Reality application improves the quality of my learning	4.23	0.92
P7	Virtual Reality application is beneficial for learning anatomy	4.64	0.58
P8	Virtual Reality application makes the anatomy learning process more effective	4.14	0.83
Total		4.18	0.86

Table 2. Respondents' Effort Expectancy

Item	Statements	Mean	SD
P9	I find it easy to learn anatomy using Virtual Reality	4.09	0.81
P10	I can use Virtual Reality easily.	4.00	0.93
P11	It takes me less time to complete anatomy learning using Virtual Reality.	3.64	0.95
P12	I feel comfortable while using Virtual Reality.	4.00	1.11
P13	I can do whatever I want within the Virtual Reality environment.	4.27	0.94
Total		4.00	0.95

According to Table 2, the respondents' mean effort expectancy score was 4.00, which indicates a high level of expectancy (X ≥ 3.67) regarding learning through virtual reality.

The next aspect assessed was the respondents' effort expectancy toward the use of virtual reality in learning. Based on Table 2, for the statement *"I can do whatever I want within the Virtual Reality environment,"* as many as 12 respondents (54.4%) strongly agreed. This may be attributed to the highly dynamic nature of virtual reality, which allows learning to take place anytime and anywhere. Moreover, the visualization in virtual reality enables users to freely explore objects. This advantage makes VR particularly suitable for learning anatomy, as explained by Moro et al. (2017), who stated that the best anatomy learning occurs when the observed structures can be viewed from all angles. Similarly, Iwanaga (2021) emphasized that mastering anatomy requires a strong understanding of three-dimensional structures.

Total of one respondent (4.5%) disagreed with the statement *"I feel comfortable while using Virtual Reality."* Prolonged use of virtual reality, in which the display is positioned directly in front of the user's eyes, may cause negative health effects such as headaches, dizziness, eye strain, blurred vision, and motion sickness (Chen et al., 2020). Similar findings were reported by Moro et al. (2017), who noted that virtual reality use can produce significant side effects, including general discomfort, headaches, dizziness, nausea, disorientation, blurred vision, difficulty focusing, and double vision related to eye health.

With advances in technology, the side effects caused by virtual reality can be minimized. Such discomfort can be reduced by increasing display resolution and decreasing latency. Virtual reality design continues to be improved to address VR-related effects, including motion sickness. One of the design strategies to mitigate these issues involves providing visual fixation points—such as the user's nose, hands, or other virtual objects—to help reduce motion sickness (Chen et al., 2020).

Conclusion

The development of virtual reality applications requires further refinement to facilitate students' learning as an additional method beyond conventional approaches such as textbooks or laboratory practice. Medical students of the Medical Education Study Program, Faculty of Medicine and Health Sciences, University of Mataram, demonstrated high expectations toward the use of virtual reality in anatomy learning. This is reflected in the mean score of 4.18 for performance expectancy and 4.00 for effort expectancy, both of which fall into the high category. These findings indicate that virtual reality, as a complementary learning tool, is well accepted by students.

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I.L.H, G.W.W, M.F: Preparation of the first draft, results, discussion, methodology, conclusion, review, and editing

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Conflicts of interest
The authors declare no conflict of interest.

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