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Navigating Virtual Reality: Exploring the Effectiveness and Challenges of VR Integration in Medical Faculty Warmadewa University

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Abstract: Virtual Reality (VR) technology has emerged as a promising tool in medical education, offering immersive and interactive learning experiences that surpass traditional teaching methods. This study investigates the effectiveness, barriers, and enablers of VR implementation in the medical faculty at Warmadewa University Denpasar, Indonesia. Participants included 30 second-year medical students and 30 teachers specializing in various medical disciplines. Before completing the Anatomy VR Learning Experience Questionnaire (AVRLEQ), students engaged with VR software for anatomy learning, and teachers used the VR technology before completing the Barriers and Enablers to the Use of Virtual Worlds in Higher Education Questionnaire to identify challenges and facilitating factors. Students reported high levels of presence and immersion in the virtual environment, with mean AVRLEQ scores between 4.09 and 4.67. They also showed increased engagement and focus during VR sessions, with mean scores of 4.23 for engagement and 4.96 for focus. Teachers reported that VR is highly regarded in medical education, with a mean Likert scale score of 4.75. This highlights its essential role in modern pedagogy. Its ability to clarify complex medical environments and equipment, with a mean score of 4.38, enhances student comprehension and familiarity with clinical settings. The study underscores the potential benefits of integrating VR technology into medical education, such as improved learning outcomes and increased student engagement. However, it also emphasizes the importance of addressing barriers through adequate training and support mechanisms. These insights are valuable for educators and policymakers aiming to enhance medical education with innovative technologies like VR.

Keywords: Virtual Reality, Medical Education, VR Effectiveness, VR Challenges

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Introduction

Virtual Reality (VR) technology has emerged as a promising tool in the realm of medical education, offering immersive and interactive learning experiences that transcend traditional teaching methods (Tang et al., 2022). With its ability to simulate realistic scenarios and intricate anatomical structures, VR holds immense potential to revolutionize how medical students learn and practice essential skills (Sabbagh et al., 2020).

In recent years, there has been a growing interest in exploring the effectiveness of VR in medical faculties, along with identifying the barriers and enablers that influence its integration into educational settings (Gregory et al., 2015; Wong et al., 2018). This interest stems from the recognition of the pressing need to enhance medical education methodologies to meet the evolving demands of healthcare practice (Swanwick, 2018).

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VR offers several advantages over conventional teaching approaches in medical education. It enables students to engage in hands-on learning experiences in a safe and controlled environment, allowing them to practice clinical procedures, surgical techniques, and diagnostic skills without risking patient safety (Ammanuel et al., 2019). Moreover, VR simulations can be tailored to cater to different learning styles and competency levels, fostering personalized learning experiences for students.

Despite the potential benefits, the widespread adoption of VR technology in medical faculties faces various challenges. These barriers may include technical limitations, such as the high cost of VR equipment and software, as well as concerns regarding the integration of VR into existing curricula and educational frameworks (Mehrfard et al., 2021; Samadbeik et al., 2018). Additionally, there may be resistance from educators and students who are unfamiliar with VR technology or skeptical of its efficacy compared to traditional teaching methods (Walter et al., 2021).

However, alongside these challenges are numerous enablers that can facilitate the effective implementation of VR in medical education. Advances in VR technology have led to the development of more affordable and accessible hardware and software solutions, making it easier for institutions to incorporate VR into their educational programs (Al-Ansi et al., 2023). Furthermore, there is growing evidence supporting the effectiveness of VR in improving learning outcomes and enhancing student engagement and motivation.

In light of these considerations, this article aims to investigate the effectiveness, barriers, and enablers of VR in medical faculties. By examining the current landscape of VR integration in medical education and identifying key factors influencing its adoption, this research seeks to inform educators, curriculum developers, and policymakers on strategies to optimize the use of VR technology in medical training. Ultimately, the goal is to harness the full potential of VR to equip the next generation of healthcare professionals with the knowledge and skills necessary to deliver high-quality patient care in an increasingly complex healthcare environment.

Materials and Methods

Participants:

Total of 60 participants were recruited from the medical faculty Universitas Warmadewa (FKIK Unwar), Denpasar, Indonesia in December 2023, using convenience sampling methods. The participant consisted of 30 second year medical students and 30 teachers specializing in various disciplines within the medical field. The selection criteria for medical student participants included enrollment in the medical program and recent exposure to Anatomy VR learning sessions as part of their curriculum. Teacher participants were selected based on their roles as educators within the medical faculty, with a range of teaching experience and expertise in different subject areas. The diverse composition of participants aimed to capture a broad spectrum of perspectives on the effectiveness, barriers, and enablers of VR technology in medical education.

Procedure:

For the student cohort, participants completed the Anatomy VR Learning Experience Questionnaire (AVRLEQ), designed to gauge their perceptions and experiences with Anatomy VR learning. The questionnaire encompassed items assessing the effectiveness of VR in comprehending anatomical structures, levels of engagement during VR sessions, and overall satisfaction with the VR learning experience. Responses were recorded on a Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

Teachers were administered the Barriers and Enablers to the Use of Virtual Worlds in Higher Education Questionnaires (Gregory et al., 2015). This instrument aimed to evaluate the obstacles and facilitators influencing the integration of VR in medical education from the perspective of educators. Adapted from existing literature, the questionnaire employed Likert scale items to gauge the extent to which various factors acted as barriers or enablers to VR use, ranging from 1 (Not a Barrier/Enabler) to 5 (Major Barrier/Enabler).

Data Analysis:

Quantitative data from both questionnaires underwent thorough descriptive statistical analysis to provide a comprehensive understanding of the gathered information. This analysis included calculating measures such as means, which represent the average response or score across all participants or items, standard deviations, which indicate the dispersion or variability of the data points around the mean, and frequencies, which show the number of times a particular response or category occurs within the dataset.

Ethical Considerations:

The study obtained ethical approval from Komite Etik Penelitian Kedokteran Universitas Warmadewa with number 09/Unwar/FKIK/EC-KEPK/I/2023 prior to data collection. Participants were provided with detailed information regarding the study's objectives,

assured of confidentiality, and required to provide informed consent before participating in the research.

Result and Discussion

The research results show that the use of VR technology in teaching anatomy at FKIK Unwar provides positive results. VR software specifically designed for studying skeletal anatomy was successfully used using the Oculus Quest 2 device (Figure 1). The research respondents showed high satisfaction in using VR (table 1).

Effectiveness of Anatomy VR Learning Experience:

Result from the Likert scale questionnaire from 30 medical students following their use of VR for anatomy study revealed positive perceptions regarding VR's efficacy as a learning tool. The respondents reported high levels of presence and immersion in the virtual environment, with mean scores ranging from 4.09 to 4.67, indicating that they felt as if they were interacting with and present within the anatomical structures. Moreover, the students expressed heightened engagement and focus during VR sessions, with a mean score of 4.23 for engagement and 4.96 for focus, suggesting that the immersive nature of VR facilitated enhanced concentration and participation in the learning process.

Participants found VR to be highly usable and intuitive, with mean scores of 4.98 for ease of use and 4.44 for ease of control. Importantly, compared to traditional learning media, such as textbooks or lectures, VR was perceived as providing a more enjoyable and comprehensible learning experience, with a mean score of 4.21. Furthermore, the students believed that VR could significantly improve their understanding of anatomy (4.48), aid in memory retention (4.05), enhance visualization skills (4.81), and better prepare them for future clinical practice (4.55).

The findings underscore the promising effectiveness of VR as a learning tool in medical education like previous research (Alharbi et al., 2020; Moro, Štromberga, Raikos, et al., 2017). Participants reported notably positive perceptions, indicating a strong sense of presence and immersion within the virtual environment, fostering engagement and heightened focus during VR sessions. Moreover, VR was deemed highly usable and intuitive, surpassing traditional learning methods in terms of enjoyment and comprehension. Importantly, students recognized VR's potential to enhance their understanding of anatomy, aid memory retention, refine visualization skills, and better prepare them for clinical practice (Moro et al., 2021). These results highlight VR's capacity to revolutionize anatomical education, offering a dynamic and immersive learning experience that resonates with medical students' needs and preferences.

Figure 1. Display in Warmadewa Anatomy Skeletal VR

Table 1. Result of Anatomy VR Learning Experience Questionnaire (AVRLEQ)

No	Statement	Mean
1	I felt like I was actually in a virtual environment when using VR to study anatomy.	4,36
2	When using VR to study anatomy, I feel as if I am interacting with the environment.	4,67
3	When using VR to study anatomy, I feel as if I am present at the scene.	4,09
4	When using VR to study anatomy, I feel as if I am in a real environment.	4,17
5	I felt very engaged in learning when using VR to learn anatomy.	4,23
6	When using VR to learn anatomy, I felt more focused on the learning.	4,96
7	I find VR very easy to use when studying anatomy.	4,98
8	I found it easy to control the VR display while studying anatomy.	4,44
9	I found it very easy to understand how to use VR when studying anatomy.	4,27
10	I feel VR provides information that is easier to understand than traditional learning media when studying anatomy.	4,31
11	I feel VR provides a more enjoyable learning experience than traditional learning media when studying anatomy.	4,21
12	I feel VR can improve my understanding of anatomy better than traditional learning media.	4,48
13	I feel VR can help me remember information about anatomy better than traditional learning media	4,05

No	Statement	Mean
14	I feel that VR can improve my ability to visualize anatomy better than traditional learning media.	4,81
15	I feel VR can help me prepare for clinical practice in the future	4,55

Enablers & Barrier of VR Integration:

The results from the Likert scale survey administered to 30 medical teachers following their use of anatomy VR technology provide a compelling insight into the perceptions of educators regarding its effectiveness (table 2). Across all measured aspects, VR emerges as a highly regarded tool in medical education. With a mean Likert scale score of 4.75, VR is affirmed to have a pivotal role in the science disciplines being taught, suggesting its integration as a fundamental component of modern pedagogy. Furthermore, the technology's ability to elucidate complex medical environments and equipment, as indicated by its mean score of 4.38, underscores its utility in enhancing students' comprehension and familiarity within clinical settings.

The overwhelmingly positive responses continue, with VR being recognized as a potent motivator, scoring an impressive 4.82, and seen as fostering collaborative learning (mean score: 4.65). Perhaps most significantly, with a mean score of 4.27, VR is perceived to facilitate the transfer of learning to real-life scenarios, indicating its potential to bridge the gap between theoretical knowledge and practical application. Additionally, the technology's capacity to offer experiential and contextual learning experiences, reflected in its mean Likert score of 4.48, further solidifies its position as a transformative force in medical education. These findings has same result with previous studies, which collectively suggest that VR holds immense promise in revolutionizing anatomy education, offering immersive and engaging learning experiences that resonate deeply with both educators and students alike (Javvaji et al., 2024; Moro, Štromberga, & Stirling, 2017).

The barrier factors identified by the 30 medical teachers underscore the multifaceted challenges hindering the effective integration of VR technology into educational practices (table 2). Half of the respondents, comprising 50%, lamented the lack of adequate technology and funding support from their institutions, indicating systemic barriers that impede the adoption of VR despite its recognized benefits. Additionally, one-third of the teachers, accounting for 33%, highlighted the absence of teaching and technical support, underscoring the importance of institutional guidance and assistance in navigating the complexities of VR implementation. Moreover, a significant proportion, at 66.7%, expressed concerns about their own computing skills, suggesting a personal barrier to utilizing VR in teaching. Addressing these challenges will require concerted efforts to enhance institutional support, provide adequate funding, offer technical assistance, and invest in educator training to empower teachers with the skills and resources necessary to leverage VR technology effectively in medical education (Glegg & Levac, 2018).

Figure 2. Student (left) and Teacher (right) using VR

Table 2. Summary of enabler and barrier factors for using VR at FKIK Unwar

No	Enabler factor	Result
1	VR has a role in the science discipline that I teach	4,75
2	VR can help students recognize or understand medical places and equipment	4,38
3	VR can motivate and increase student interest	4,82
4	VR can lead to better transfer of learning to real life	4,27
5	VR can enable more effective collaborative learning	4,65
6	VR can allow students to learn experientially or contextually	4,48
	Barrier factor	
1	My institution does not provide adequate technology to use VR	50%
2	My institution does not provide funding to use VR	50%
3	My institution does not provide teaching support for using VR	33%
4	My institution does not provide technical support for using VR	33%
5	I don't have the computing skills to use VR in teaching	66,7%

Comparison and Integration of Findings:

The findings from both medical students and teachers collectively highlight the resounding agreement on the efficacy of VR technology in anatomy education. Students perceive VR as a powerful learning tool, noting heightened levels of engagement, focus, and

immersion during VR sessions. They commend its usability, intuitiveness, and ability to offer a more enjoyable and comprehensible learning experience compared to conventional methods. Moreover, students' express confidence in VR's capacity to deepen their understanding of anatomy, enhance memory retention, refine visualization skills, and better prepare them for future clinical practice. The findings corroborate previous research indicating widespread acceptance of VR technology among both medical students and educators for anatomy education (Einloft et al., 2024). Consistent with prior studies, students' positive perceptions of VR's effectiveness underscore its potential to revolutionize anatomical learning experiences by fostering engagement, comprehension, and clinical readiness (Duarte et al., 2020; Uruthiralingam & Rea, 2020).

Similarly, medical teachers corroborate these sentiments, recognizing VR's effectiveness in elucidating intricate medical environments, fostering collaborative learning environments, and facilitating the application of theoretical knowledge to real-world scenarios (Plotzky et al., 2021). Despite these positive perceptions, teachers also identify significant barriers to seamless VR integration, including insufficient technology and funding support, a dearth of teaching and technical assistance, and concerns about personal computing skills. Both students and teachers stress the critical role of institutional support, adequate funding, technical guidance, and educator training in surmounting these obstacles and harnessing the transformative potential of VR in medical education. This underscores the imperative for collaborative efforts among stakeholders to fully leverage VR technology and optimize anatomy learning experiences.

While the findings from both medical students and teachers paint a promising picture of the effectiveness and potential of VR technology in anatomy education, it's important to acknowledge certain limitations. First, the sample sizes of both student and teacher groups may not be fully representative of the broader population of medical education stakeholders. Additionally, the Likert scale questionnaire used to assess perceptions may not capture the full spectrum of attitudes and experiences regarding VR integration. Moreover, the study primarily focuses on perceptions and may lack objective measures of learning outcomes or long-term retention of knowledge. Furthermore, the study may be subject to response bias, as participants may provide socially desirable responses or may not fully disclose their true opinions. Finally, the study does not explore potential disparities in access to VR technology among different institutions or regions, which could impact its widespread adoption and effectiveness. Addressing these limitations through larger, more diverse samples, mixed-methods approaches, and longitudinal studies could provide a more comprehensive understanding of the challenges and opportunities associated with integrating VR into medical education.

In future research, aspects such as learning effectiveness, comparison with conventional learning methods, and the long-term impact of using VR in anatomy learning on the clinical abilities of medical students can be explored. Thus, the use of VR in medical education can continue to be improved and optimized, according to the needs and demands of the continuously developing medical education context.

Conclusion

The use of VR in anatomy learning at FKIK Unwar has the potential to improve the quality of learning, improve students' learning experiences, and motivate and increase their interest in the subject matter. The research results also show that VR can provide a more interactive, immersive and realistic learning experience in understanding the structure of the human body. It is worth noting some of the inhibiting factors identified in this research, especially those related to computational skills in using VR as a teaching tool. Therefore, medical education institutions need to provide adequate training and support to lecturers and students in overcoming this challenge.

Acknowledgements

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