Literature Review: Immersive Technology as a Teaching Aid in the Health Sector

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Abstract

The increasing complexity of healthcare education and the limitations of traditional teaching methods necessitate innovative approaches to meet global demands for skilled professionals. Immersive technologies, including Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), and Extended Reality (XR), offer transformative potential by providing interactive, lifelike simulations that bridge theoretical knowledge and practical skills. This study employs a systematic literature review alongside case studies and interviews with educators and students to assess the effectiveness of these technologies in healthcare training. Results reveal significant improvements in learner engagement, conceptual understanding, skill acquisition, and empathy, with particular benefits for inclusive and adaptive learning. However, barriers such as high costs, accessibility challenges, and ethical concerns persist, limiting widespread implementation. Practical recommendations are proposed to overcome these challenges through scalable, cost-effective solutions and interdisciplinary collaboration. This research highlights the global potential of immersive technologies to revolutionize healthcare education, fostering equity, inclusivity, and the development of a competent and empathetic healthcare workforce.

1. Introduction

The health sector faces challenges in providing quality education due to its vast geography and diverse population (Motley et al., 2024). Traditional teaching methods often struggle to meet the growing demand for skilled healthcare professionals, particularly in remote areas. Immersive technologies such as Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) offer a promising solution by providing interactive, lifelike simulations that enhance learning and bridge the gap between theoretical knowledge and practical application (Department of Veterans Affairs, 2024). These technologies allow students to practice medical skills in a risk-free environment, improving their readiness for real-world scenarios (Bruening et al., 2018).

The purpose of this study is to explore the role of immersive technologies in healthcare education, assess their impact on learning outcomes, and identify barriers to their implementation. By examining how VR, AR, and MR are currently used, the study aims to provide insights into how these technologies can enhance healthcare training in the country. The research will also offer recommendations on how to overcome challenges and effectively integrate immersive technologies into Indonesia's healthcare education system.

Through a review of existing literature, case studies, and interviews with educators and students, this study seeks to assess the feasibility and effectiveness of immersive technology in healthcare training, contributing to the improvement of healthcare education.

1.1 Literature Review

The literature on immersive technology in education highlights several transformative benefits and challenges. Immersive technologies, such as Virtual Reality (VR) and Augmented Reality (AR), have been shown to significantly enhance student engagement by creating interactive and immersive learning environments. Studies reviewed by (Lin et al., 2024) underscore the potential of these technologies to improve cognitive, behavioural, and affective engagement. Specifically, VR and AR promote focused attention, deepen conceptual understanding, and motivate students to participate actively in the learning process. Additionally, research indicates that immersive technologies are particularly effective for students with learning disabilities, as they offer personalised and adaptive learning experiences that traditional methods often fail to provide. Additionally, In the last six years, 107 Scopus indexed articles and 200 relevant Crossref indexed papers were found. Of the 200 Crossref papers, 86% (172 papers) discussed immersion based on their titles, while of the 107 Scopus papers, only 23% (25 papers) focused on immersion. These data show that research on Immersion is a topic that attracts attention (Adisusilo & Soebandhi, 2021).

Furthermore, the application of VR and AR in health education has demonstrated promising results in promoting behavioural changes and improving health knowledge among students and the wider population. According to (Tene et al., 2024), these technologies excel in fostering empathy—an essential component of health education. Through immersive simulations, users can experience scenarios from the perspective of individuals with chronic diseases or other health conditions, leading to a deeper understanding of the consequences of unhealthy behaviours and the value of adopting healthier lifestyles (Xu et al., 2021). By bridging the gap between theoretical knowledge and practical awareness, immersive technologies facilitate a more impactful learning experience, empowering users to translate health information into meaningful actions (Hussain et al., 2021).

Despite these benefits, challenges remain. The cost and accessibility of immersive technology can limit its widespread adoption, particularly in resource-constrained settings. Moreover, the literature reveals gaps in understanding the long-term effects of immersive learning on sustained behaviour change and knowledge retention (Alzahrani, 2020). These areas warrant further investigation to maximise the potential of immersive technology in both education and health contexts.

2. Research Methods

This research employs a systematic literature review approach to explore the use of immersive technologies, such as Virtual Reality (VR) and Augmented Reality (AR), in health education. The primary focus is to examine how these technologies are being applied to enhance teaching and learning within the health sector. The review aims to assess the effectiveness of immersive technologies in supporting the development of healthcare professionals and improving learning outcomes in medical and healthcare training programs.

The review process involved selecting studies based on specific inclusion criteria:

1. Peer-reviewed journal articles published within the last five years.
2. Studies that addressed the application of immersive technologies in health education or training.
3. Studies that included students or trainees in the healthcare field as the primary sample.

Through this review, the research seeks to analyze the role of immersive technologies in health education and identify potential gaps in the current application, as well as areas for further development.

For data collection, relevant studies were sourced from multiple academic databases, including Google Scholar and the Indonesian National Library's e-resources portal. These platforms provided a broad selection of peer-reviewed journal articles, conference papers, and reports, ensuring a comprehensive review of recent research on immersive technologies in health education. The studies were selected based on their relevance to the application of immersive technologies like VR and AR in healthcare training and education.

3. Result and Discussion

The integration of immersive technologies in education, particularly in healthcare, has attracted significant attention in recent years. Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) have demonstrated transformative potential, offering innovative ways to bridge the gap between theoretical knowledge and practical applications. The following provides a comprehensive literature review, summarizing key studies exploring the applications, benefits, and challenges of immersive technologies as teaching aids in the healthcare sector. The findings highlight opportunities for improving education and barriers that must be addressed to maximize impact.

Immersive technologies, including VR, AR, and MR, hold significant potential in revolutionizing education across various disciplines. They enhance professional training and foster empathy, particularly in healthcare and nursing education, where they improve critical reasoning, problem-solving, and interpersonal skills while addressing ethical considerations in their application (Binytska et al., 2022; Sombilon et al., 2024). The metaverse, integrating these technologies, supports simulation-based training and collaborative learning, offering innovative possibilities for enhancing medical education and clinical care by improving access for remote or underserved populations (Díaz-Chieng et al., 2022; Lewis et al., 2024; Tan et al., 2022).

In science education, immersive VR shows a notable positive impact on learning performance, especially among younger learners, by enabling better visualization and engagement (Andalib & Monsur, 2024; Bower & Jong, 2020). Similarly, in healthcare education, XR-based tools such as Head-Mounted Displays (HMDs) facilitate understanding complex 3D structures and repeated practice in areas like surgery and anatomy, making education more effective and scalable with advances in computational capacity (Barteit et al., 2021; Kassutto et al., 2021). For cognitive tasks requiring spatial understanding, immersive VR aids in skill acquisition that seamlessly transfers to real-world scenarios, emphasizing its transformative potential (Blair et al., 2021; Hamilton et al., 2021).

Immersive storytelling techniques, leveraging attributes like interaction and imagination, deepen motivation and problem-solving abilities, allowing learners to grasp complex concepts better (Hardie et al., 2020). Furthermore, VR platforms like MVTECH create immersive, interactive learning environments, potentially transforming traditional education by enabling portable and on-demand training while aligning with strong pedagogical theories for improved learning outcomes (Alkhwaldi, 2024; Logeswaran et al., 2021).

Although the metaverse cannot replace direct clinical practice, it serves as a valuable tool for developing essential patient interaction skills in a controlled, adaptable setting, thereby enriching education and patient care (Suh et al., 2023). The continuous development of immersive technologies promises to enhance education's quality, accessibility, and engagement, ensuring impactful learning experiences across diverse fields (Mäkinen et al., 2020; Wu et al., 2021).

While immersive technologies show promise for enhancing education, several challenges must be addressed for their effective integration. These challenges include cybersecurity, privacy concerns, and accessibility, which must be carefully managed to ensure safe and inclusive learning environments (Díaz-Chieng et al., 2022; Tan et al., 2022). Additionally, there is a need for further research to develop frameworks that optimize the use of immersive technologies across various disciplines, educational levels, and medical fields like pediatrics (Barteit et al., 2021; Kushnir et al., 2024) .

Ethical considerations are another critical aspect, particularly in healthcare and nursing education, where interdisciplinary collaboration is required to design immersive environments that support future training while safeguarding user well-being (Sombilon et al., 2024). The development of soft skills, such as empathy and cultural understanding, through immersive technologies also requires more investigation to fully explore their potential impact (Bower & Jong, 2020; Jones et al., 2021).

Moreover, while there is a growing interest in the benefits of immersive virtual learning, challenges such as traditional teaching models, assessment systems, and the lack of large-scale trials hinder broader adoption (Blair et al., 2021; Hopp et al., 2020). Effective integration of VR, AR, and alternative reality games needs to align with specific educational objectives and learner needs, ensuring pedagogical effectiveness and positive learning outcomes (Andalib & Monsur, 2024; Kassutto et al., 2021).

Finally, to fully realize the potential of immersive technologies in education, ongoing research and technological advancements are necessary to improve user experience (UX) and explore their application in real-world settings (Hamilton et al., 2021; Mäkinen et al., 2020). Longitudinal studies with diverse populations will be crucial to understanding the long-term benefits, especially in healthcare contexts, and ensuring that immersive technologies contribute meaningfully to education and well-being (Phiri et al., 2024).

Immersive technologies like VR, AR, and XR present significant opportunities to transform education and health sectors by enhancing engagement, empathy, and skill development. VR demonstrates strong potential in procedural and spatial tasks, AR enhances visualization and accessibility, while XR integrates these capabilities for interactive learning. Despite these benefits, challenges such as ethical concerns, technical constraints, and financial barriers persist. The findings, summarized in a comparative bar chart in Fig. 1, illustrate how VR, AR, and XR differ in their potential to promote health education and behavioral change, revealing patterns of high, medium, and low impact across different applications.

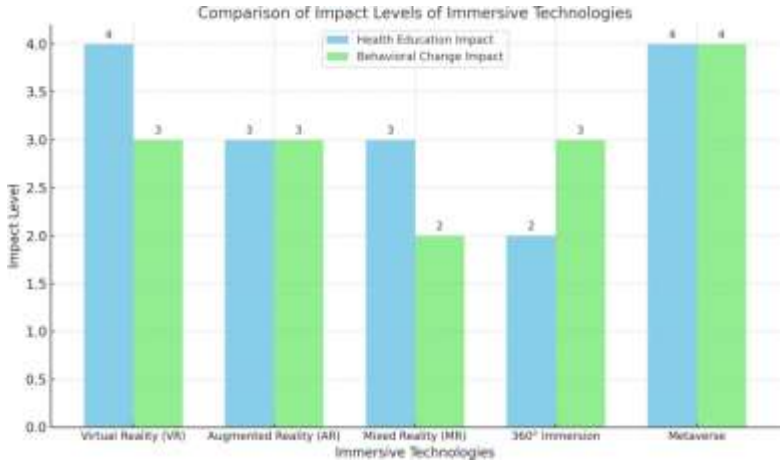

Fig. 1 Comparison Chart of Impact Levels of Immersive Technologies

The calculation for the Fig. 1 chart involves assessing and categorizing the impact levels (high, medium, low) of immersive technologies—VR, AR, and XR—on health education and behavioral change based on key studies. Each study was reviewed to identify its primary focus, outcomes, and reported effectiveness of the technology. These were then classified into the three levels of impact. For example, VR consistently showed a high impact on procedural learning and empathy, AR demonstrated medium impact through accessibility and visualization, and XR provided integrated benefits with a medium to high impact depending on the context. These categorizations were aggregated to produce a comparative visualization, highlighting the strengths and limitations of each technology.

4. Conclusions

The research highlights the transformative potential of immersive technologies—such as Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), and the Metaverse—in healthcare education. These technologies offer significant benefits, including enhanced visualization, immersive learning environments, and the development of critical skills like empathy, problem-solving, and technical expertise. For disciplines like nursing, dementia care, and surgical training, immersive tools provide unique opportunities for learners to gain practical, interactive experiences in risk-free, adaptable settings. Additionally, they support innovative pedagogical approaches, fostering interdisciplinary collaboration and learner-centered methodologies that enrich educational outcomes.

Despite their promise, implementing immersive technologies in healthcare education presents challenges, such as ethical concerns, privacy issues, technical and financial barriers, and the need for theoretical and empirical foundations. Addressing these obstacles requires interdisciplinary collaboration, scalable solutions, and rigorous research to establish best practices and optimize usability. Future researchers should prioritize longitudinal studies and explore soft-skill development to broaden the scope and efficacy of these tools.

For general readers and aspiring scholars, this analysis underscores the need for a balanced approach to adopting technology in education. While the potential is immense, careful planning, ethical consideration, and robust evaluations are vital for meaningful integration. Writing about such advancements is rewarding but demands dedication, critical thinking, and sufficient time to craft a comprehensive and insightful analysis.

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