ASCILITE 2024

Navigating the Terrain:

Emerging Frontiers in Learning Spaces, Pedagogies, and Technologies

Designing Immersive Reality Environments in Healthcare Education: A Proposed Research Framework

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This paper presents a proposed research framework aimed at addressing the critical need for innovative approaches in healthcare education by exploring the implementation of Augmented Reality (AR) and Virtual Reality (VR) technologies across Australasia. Utilizing an Educational Design Research (EDR) methodology, the proposed study seeks to develop a comprehensive, context-sensitive framework for the effective integration of AR and VR in healthcare curricula. The study navigates the unique challenges posed by Australasia's diverse cultural landscape, varying resource availability, and distinct institutional policies. Through iterative cycles of analysis, design, development, and evaluation, the proposed research intends to create and assess contextualized AR/VR experiences, their impact on student learning outcomes, and their potential to enhance healthcare education quality. The resulting framework and guidelines are intended to serve as a robust foundation for healthcare institutions across Australasia, potentially revolutionising healthcare professional training and ultimately contributing to improved patient care and public health outcomes. This proposed research not only addresses a significant gap in the current literature but also provides practical, evidence-based solutions for the successful adoption of cutting-edge technologies in healthcare education. Finally, the proposed framework generalisability to a global context focusing on the United Nations Sustainable Development Goals of quality education and good health for all.

Keywords: Augmented Reality, Virtual Reality, Healthcare Education, Educational Design Research, Authentic Learning, Technology Integration, Sustainable Development Goals

Introduction

The landscape of healthcare education is rapidly evolving, driven by technological advancements and the increasing complexity of healthcare delivery. Among the most promising innovations are Augmented Reality (AR) and Virtual Reality (VR) technologies, which offer immense potential for enhancing student learning, engagement, and skill development in healthcare education (Dhar et al., 2023; Aiello et al., 2023). These technologies can provide immersive, interactive experiences that can simulate real-world healthcare scenarios, potentially allowing students to practice complex procedures and decision-making in safe, controlled environments (Dogan et al., 2024). However, the successful adoption and integration of AR and VR technologies in healthcare education is not without challenges. It requires a comprehensive and contextually relevant approach that addresses a myriad of pedagogical, technical, and institutional factors (Herrington & Herrington, 2006). The complexity of this integration may be particularly pronounced in diverse regions like Australasia, where cultural nuances, varying resource availability, and distinct institutional policies create a unique educational landscape.

The Australasian context presents specific challenges that may differentiate it from other regions:

1. Cultural Diversity: Australasia encompasses a wide range of cultures, including Indigenous populations with distinct health beliefs and practices. This diversity necessitates culturally sensitive approaches to healthcare education and technology implementation (Taylor et al., 2019).
2. Geographical Disparities: The region includes both densely populated urban areas and remote, sparsely populated regions. This geographical spread can lead to significant variations in access to technology and healthcare resources (Doig et al., 2022).
3. Policy Variations: Different countries and territories within Australasia may have varying educational and healthcare policies, potentially affecting the uniformity of AR/VR implementation across the region (Drysdale et al., 2024).
4. Resource Disparities: There can be substantial differences in technological infrastructure and financial resources between institutions and regions within Australasia (Trankle et al., 2022).
5. Unique Health Challenges: The region faces specific health issues, such as those related to indigenous health disparities, which may require tailored educational approaches (Paterson et al., 2024).

While numerous studies have explored the benefits of AR and VR in healthcare education (Kyaw et al., 2019; Moro et al., 2017), there is a notable lack of comprehensive research addressing the specific challenges and opportunities faced by Australasian institutions. Existing literature has primarily focused on isolated case studies or small-scale implementations, often not covering the broader contextual factors that influence technology adoption and effectiveness (McKenney & Reeves, 2021). This gap in knowledge leaves Australasian healthcare educators without a clear roadmap for implementing these potentially transformative technologies. The present research project aims to bridge this critical gap by developing a comprehensive framework for the implementation of AR and VR technologies in healthcare education programs across Australasia. By employing an Educational Design Research (EDR) methodology, this study ensures a systematic, evidence-based approach to guide the effective integration of these technologies in healthcare curricula.

The objectives of this research are multifaceted:

1. To conduct a thorough analysis of the current state of AR and VR adoption in Australasian healthcare education, identifying key challenges, barriers, and enablers.
2. To explore the unique contextual factors influencing AR/VR implementation in Australasia, including cultural diversity, resource constraints, and institutional policies.
3. To design and develop contextually relevant AR and VR experiences aligned with specific learning objectives and authentic assessment practices in healthcare education.
4. To evaluate the effectiveness of these AR/VR experiences in enhancing student learning, engagement, and skill development through iterative cycles of prototyping, testing, and refinement.
5. To develop a comprehensive framework and guidelines for AR/VR implementation in Australasian healthcare education, considering pedagogical, technical, and contextual considerations.
6. To disseminate the research findings and developed framework to promote effective and sustainable adoption of AR/VR technologies in healthcare education across Australasia.

This research is grounded in established educational theories, including Bruner's (1966) constructivist approach to learning, Vygotsky's (1978) sociocultural theory, and the principles of authentic learning as described by Herrington and Herrington (2006). These theoretical foundations aim to inform the design and development of AR/VR experiences that not only leverage the technological capabilities but also align with evidence-based pedagogical practices. The significance of this research lies in its potential to transform healthcare education in Australasia and beyond. By providing a robust, context-sensitive framework for AR/VR integration, this study seeks to equip healthcare educators with the tools and knowledge needed to effectively implement these technologies. The goal is to enhance the quality of

healthcare education, leading to better-prepared healthcare professionals and, consequently, improved patient care and public health outcomes.

Methods Used

The research project employs the Educational Design Research (EDR) methodology, a systematic and flexible approach well-suited for addressing complex educational problems and developing practical, theory-informed solutions (McKenney & Reeves, 2021). EDR is characterized by its iterative nature, involving cycles of analysis, design, development, implementation, and evaluation. This approach allows for continuous refinement of the developed solutions based on empirical evidence and stakeholder feedback.

The project is structured into four main phases, each with specific objectives and methodologies:

Analysis and Exploration Phase (Months 1-6):

- Comprehensive literature review: A systematic review of existing research on AR/VR in healthcare education, with a focus on implementation challenges and successes in diverse contexts (Barsom et al., 2016; Cook et al., 2011).
- Stakeholder engagement: Conducting semi-structured interviews and focus groups with healthcare educators, students, administrators, and industry partners across Australasia. This will provide insights into current practices, perceived challenges, and opportunities for AR/VR integration.
- Curriculum analysis: A detailed examination of existing curricula, learning objectives, and assessment practices in healthcare education programs across Australasia, identifying potential areas for AR/VR integration.
- Contextual analysis: Investigating the unique cultural, institutional, and resource-related factors that may influence AR/VR implementation in Australasian healthcare education (Fowler, 2014).

Design and Development Phase (Months 7-15):

- Development of design principles: Based on the findings from the analysis phase, creating a set of design principles and guidelines for effective AR/VR experiences in healthcare education (Dalgarno & Lee, 2010).
- Collaborative prototyping: Working with interdisciplinary teams (including subject matter experts, instructional designers, and software developers) to design and prototype AR/VR experiences aligned with specific learning objectives (Huang et al., 2010).
- Iterative refinement: Conducting multiple cycles of testing and refinement, incorporating feedback from stakeholders and end-users to improve the AR/VR prototypes.

Implementation and Evaluation Phase (Months 16-24):

- Pilot implementation: Implementing the developed AR/VR experiences in selected healthcare education programs across Australasia.
- Mixed-methods evaluation: Employing a combination of quantitative and qualitative methods to assess the effectiveness of the AR/VR experiences (Merchant et al., 2014). This includes:
    - Pre- and post-intervention surveys to measure changes in student knowledge, skills, and attitudes.
    - Performance assessments to evaluate skill development (Rushforth, H. E. 2007; Hodges, B. 2003)
    - Qualitative interviews and focus groups to gather in-depth insights on user experiences.
    - Analysis of learning analytics data from the AR/VR platforms
    - Formative evaluations: Conducting ongoing assessments throughout the implementation to identify areas for improvement and make necessary adjustments.

Reflection and Dissemination Phase (Months 25-36):

- Data analysis and synthesis: Comprehensive analysis of the quantitative and qualitative data collected during the implementation and evaluation phase.
- Framework development: Based on the research findings, developing a comprehensive framework for AR/VR implementation in Australasian healthcare education.
- Guideline creation: Producing detailed guidelines and best practices for designing, developing, and implementing AR/VR experiences in healthcare education.
- Dissemination: Sharing the research findings and developed framework through multiple channels, including: Academic publications in peer-reviewed journals; Presentations at national and international conferences; Workshops and professional development sessions for healthcare educators; Online resources and open educational materials; and, Collaborations with industry partners and professional associations

The research team comprises experts in healthcare education, educational technology, instructional design, and AR/VR development (Fig. 1). This transdisciplinary composition ensures a holistic approach to the research problem. Partnerships with healthcare institutions, professional associations, and technology companies provide access to essential resources, subject matter expertise, and potential avenues for implementation and dissemination. Ethical considerations are paramount throughout the research process. The study will adhere to the ethical guidelines set forth by the Australian Code for the Responsible Conduct of Research and obtain approval from relevant institutional review boards. Particular attention will be paid to issues of data privacy, informed consent, and the potential risks associated with AR/VR use in educational settings.

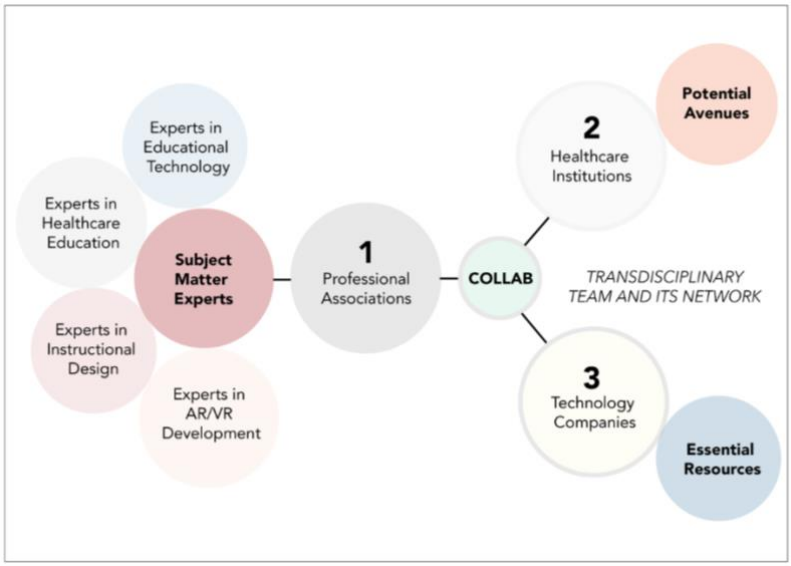

Fig. 1 Transdisciplinary team and expert's network

Results

As this is a proposal for future research, specific results are not yet available. However, based on the comprehensive methodology and objectives outlined, the anticipated outcomes of the project include:

1. A detailed mapping of the current state of AR/VR adoption in Australasian healthcare education, including identified challenges, barriers, and enablers specific to the region.
2. A contextualized framework for effective integration of AR/VR technologies in healthcare curricula, tailored to the unique needs and constraints of Australasian institutions.

3. A set of empirically validated design principles and guidelines for creating effective AR/VR experiences in healthcare education.
4. Quantitative and qualitative evidence on the effectiveness of AR/VR experiences in enhancing student learning outcomes, engagement, and skill development in healthcare education.
5. Insights into the cost-effectiveness and return on investment of AR/VR implementation in healthcare education programs.
6. A collection of case studies demonstrating successful AR/VR integration in various healthcare education contexts across Australasia.
7. A comprehensive set of resources, including implementation guides, best practice recommendations, and professional development materials, to support the adoption of AR/VR technologies in healthcare education

Table 1
Anticipated Project Timeline and Key Deliverables

Phase	Duration	Key Activities	Expected Deliverables
Analysis and Exploration	Months 1-6	Literature review, stakeholder engagement, curriculum analysis	Comprehensive report on current state of AR/VR in Australasian healthcare education
Design and Development	Months 7-15	Prototyping AR/VR experiences, iterative refinement	Set of design principles, Prototype AR/VR experiences
Implementation and Evaluation	Months 16-24	Implementation in selected programs, mixed-methods evaluation	Evaluation report, Refined AR/VR experiences
Reflection and Dissemination	Months 25-36	Framework development, result dissemination	Comprehensive framework, Guidelines, Academic publications

Furthermore, the project's emphasis on cost-effective strategies and return on investment addresses a critical concern for many institutions considering the adoption of AR and VR technologies. By providing evidence-based insights into the financial feasibility and sustainability of these implementations, the research can inform decision-making processes and resource allocation at institutional and policy levels. This practical focus enhances the likelihood of widespread adoption and long-term impact of the research findings. The dissemination strategy, which includes academic publications, workshops, online resources, and industry collaborations, ensures that the project's findings and developed solutions will reach a wide audience. This multi-faceted approach to knowledge sharing has the potential to accelerate the adoption of AR and VR technologies in healthcare education across the region and contribute to the ongoing improvement of healthcare professional training. However, it is important to acknowledge potential limitations and challenges of the research. The diversity within Australasia may make it difficult to create a one-size-fits-all solution, and the rapid pace of technological advancement could potentially outpace the research timeline. Additionally, the successful implementation of AR/VR technologies depends on factors beyond the scope of this study, such as institutional readiness and broader healthcare policies. Future research directions could include longitudinal studies to assess the long-term impact of AR/VR integration on healthcare education outcomes and professional practice. Additionally, comparative studies with other regions could provide insights into the global applicability of the developed framework.

Evaluation of Framework Generalisability

To assess the proposed framework's generalisability to a global context, particularly in relation to the United Nations Sustainable Development Goals (SDGs) of quality education (SDG 4) and good health and well-being (SDG 3), we present the following detailed evaluation table:

Table 2
Framework Generalisability Evaluation

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Aspect	SDG Alignment	Global Applicability	Potential Challenges	Mitigation Strategies
Contextual Relevance	High - Addresses specific needs of diverse populations (SDG 4.5, 4.7)	Medium - May require adaptation for different cultural contexts	Varying cultural norms and educational traditions	Develop modular framework components that can be customized for different contexts
Cost-effectiveness	High - Promotes efficient use of resources (SDG 4.a, 3.c)	High - Applicable to both resource-rich and resource-constrained settings	Differing economic conditions and healthcare priorities	Provide scalable solutions and guidelines for low-resource implementations
Pedagogical Approach	High - Enhances quality of healthcare education (SDG 4.3, 4.4)	High - Based on universal learning principles	Variations in educational systems and teaching philosophies	Emphasize adaptable pedagogical strategies and provide training for educators
Technological Integration	Medium - Depends on availability of AR/VR technologies (SDG 4.4, 9.c)	Medium - Requires certain level of technological readiness	Uneven distribution of technological resources globally	Develop guidelines for alternative low-tech solutions and gradual technology adoption
Interdisciplinary Collaboration	High - Promotes holistic approach to healthcare education (SDG 4.7, 17.16)	High - Applicable across various healthcare disciplines	Potential silos between disciplines in some contexts	Provide strategies for fostering interdisciplinary collaboration and communication
Scalability	Medium - Framework adaptable to different scales (SDG 4.1, 4.3)	Medium - May require modifications for very large or small implementations	Varying institutional capacities and regulatory environments	Develop guidelines for scaling implementations and adapting to different institutional sizes
Focus on Health Outcomes	High - Directly contributes to improving healthcare quality (SDG 3.8, 3.c)	High - Addresses universal need for skilled healthcare professionals	Differences in healthcare systems and priorities globally	Emphasize core competencies relevant across different healthcare systems
Cultural Sensitivity	High - Considers diverse cultural contexts (SDG 4.7, 10.2)	Medium - Requires careful adaptation to different cultural norms	Potential for cultural misunderstandings or inappropriate content	Provide guidelines for cultural adaptation and involve local stakeholders in content development
Accessibility	Medium - Considers diverse learning needs (SDG 4.5, 10.2)	Medium - May require adaptations for learners with disabilities	Varying levels of support for inclusive education globally	Develop guidelines for creating accessible AR/VR experiences and alternative learning pathways

Sustainability	High - Promotes long-term improvements in education quality (SDG 4.7, 12.8)	Medium - Requires ongoing support and updates	Rapid technological changes and evolving healthcare practices	Provide strategies for sustainable implementation and continuous improvement of AR/VR tech and its experiences

The potential impact of this research extends beyond the immediate realm of healthcare education. By improving the quality and effectiveness of healthcare professional training, this project indirectly contributes to several of the United Nations Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-being) and SDG 4 (Quality Education). The development of a framework for AR/VR integration in healthcare education aligns with the targets of ensuring inclusive and quality education for all (SDG 4.3) and increasing the supply of qualified health professionals (SDG 3.c). One of the key strengths of the proposed framework is its potential adaptability to different healthcare disciplines. While the initial focus is on Australasian contexts, the principles and methodologies developed could be applicable to a wide range of healthcare fields, from nursing and medicine to allied health professions. This broad applicability is crucial in addressing the diverse and evolving needs of the healthcare sector. The emphasis on authentic learning experiences through AR/VR technologies is particularly significant. As Herrington and Herrington (2006) argue, authentic learning environments are essential for developing the complex thinking and problem-solving skills required in real-world professional practice. By simulating realistic healthcare scenarios, AR/VR experiences can bridge the gap between theoretical knowledge and practical application, potentially leading to better-prepared healthcare professionals (Seymour et al., 2002).

However, it is important to acknowledge potential challenges and limitations of the research which are listed below (Fowler, 2015; Barsom et al., 2016):

1. Technological barriers: The successful implementation of AR/VR technologies depends on adequate technological infrastructure and support. Some institutions, particularly in resource-constrained settings, may face challenges in adopting these technologies.
2. Resistance to change: As with any significant educational innovation, there may be resistance from some educators or institutions who are comfortable with traditional teaching methods. Addressing this resistance through evidence-based advocacy and professional development will be crucial.
3. Rapid technological advancement: The fast-paced nature of technological development in AR/VR could potentially outpace the research timeline, necessitating flexibility and adaptability in the framework development.
4. Ethical considerations: The use of immersive technologies in healthcare education raises important ethical questions, such as patient privacy in simulated scenarios and the psychological impact of highly realistic simulations on students. These ethical dimensions will need careful consideration throughout the research process.
5. Long-term effectiveness: While the study aims to evaluate the immediate impact of AR/VR integration, the long-term effects on healthcare professional competence and patient outcomes will require extended longitudinal studies beyond the scope of this project.

To address these challenges, the research design incorporates several mitigation strategies:

a. Scalable solutions: The framework will include guidelines for implementing AR/VR experiences across a spectrum of technological capabilities, from high-end systems to more accessible mobile-based solutions.

b. Stakeholder engagement: Continuous involvement of educators, administrators, and students throughout the research process will help address concerns and build buy-in for the developed solutions.
c. Flexibility in framework design: The framework will be designed with modularity and adaptability in mind, allowing for easy updates as technology evolves.
d. Ethical guidelines: Development of comprehensive ethical guidelines for AR/VR use in healthcare education will be an integral part of the framework.
e. Foundation for longitudinal research: While long-term outcomes are beyond the immediate scope, the project will establish baseline data and methodologies to facilitate future longitudinal studies.

This project lays the groundwork for several promising avenues of future research (Cook et al., 2011):

1. Longitudinal studies: Long-term follow-up studies to assess the impact of AR/VR-enhanced education on healthcare professionals' competence and patient outcomes.
2. Cross-cultural adaptations: Comparative studies to explore how the framework can be adapted for healthcare education in different cultural and socioeconomic contexts globally.
3. Interprofessional education: Investigation of how AR/VR technologies can facilitate interprofessional learning experiences in healthcare education.
4. AI integration: Exploration of the potential synergies between AR/VR technologies and artificial intelligence in creating adaptive, personalized learning experiences for healthcare students.
5. Patient involvement: Research into how AR/VR technologies can be used to involve patients in healthcare education, potentially improving patient-centered care practices.
6. Continuing professional development: Studies on the application of the AR/VR framework for ongoing professional development of practicing healthcare professionals.

Discussion

The proposed research project addresses a significant gap in knowledge regarding the implementation of AR and VR technologies in healthcare education within the Australasian context. By employing an EDR approach, this study aims to develop practical, evidence-based solutions that are grounded in theory and responsive to the unique challenges and opportunities present in the region. One of the key strengths of this research lies in its focus on contextual relevance. Unlike previous studies that have often overlooked the specific needs and constraints of Australasian institutions, this project explicitly considers factors such as cultural diversity, resource limitations, and institutional policies. This approach aligns with Vygotsky's (1978) sociocultural theory, which emphasizes the importance of cultural context in learning and development. By tailoring the AR/VR implementation framework to the Australasian context, the resulting solutions are expected to be more applicable and effective in real-world settings. The transdisciplinary nature of the research team and the collaborative approach with stakeholders are crucial aspects of this study. This aligns with the principles of EDR and is expected to lead to innovative solutions that address the multifaceted nature of AR/VR implementation in healthcare education. By bringing together experts from various fields and engaging with end-users throughout the research process, the project ensures that the developed framework and guidelines will be both theoretically sound and practically relevant to educators, administrators, and policymakers in the healthcare education sector. The iterative and participatory nature of the EDR methodology is particularly valuable in the rapidly evolving field of educational technology. This approach allows for continuous refinement and adaptation of the developed solutions based on empirical data and stakeholder feedback. As McKenney and Reeves (2022) note, this flexibility is crucial when dealing with complex educational interventions, especially those involving emerging technologies like AR and VR. The anticipated advances in knowledge resulting from this project have the potential to significantly impact healthcare education in Australasia and beyond. The comprehensive framework and guidelines for AR/VR implementation can serve as a valuable resource for institutions seeking to enhance their educational

programs and prepare healthcare professionals for the challenges of 21st century practice. This aligns with the broader goals of improving the quality of healthcare education and, ultimately, patient care outcomes.

Conclusions

The implementation of AR and VR technologies in healthcare education represents a significant opportunity to enhance the quality and effectiveness of professional training. This proposed research project, grounded in Educational Design Research methodology and focused on the Australasian context, aims to develop a comprehensive, evidence-based framework for successful AR/VR integration. By addressing the unique challenges and opportunities present in Australasian healthcare education, this study intends to fill a critical gap in the current literature. The resulting framework and guidelines, if successful, could contribute to revolutionize healthcare education practices, potentially leading to better-prepared professionals and, ultimately, improved patient care outcomes. The interdisciplinary and collaborative nature of this proposed research, combined with its iterative and context-sensitive approach, positions it to potentially make significant contributions to the fields of healthcare education and educational technology. While challenges exist, the potential benefits of successful AR/VR integration in healthcare education are substantial. As healthcare continues to evolve in complexity and scope, innovative educational approaches are essential to prepare the next generation of healthcare professionals. This proposed research project represents a crucial step towards harnessing the power of immersive technologies to meet this challenge, with potential implications not just for Australasia, but for healthcare education globally.

Based on the anticipated outcomes of this research, several key recommendations can be made:

1. Policy development: Healthcare education institutions and regulatory bodies should consider developing policies that support and guide the integration of AR/VR technologies in curricula.
2. Investment in infrastructure: Institutions should plan for strategic investments in the technological infrastructure necessary to support AR/VR implementation.
3. Professional development: Comprehensive professional development programs should be established to equip healthcare educators with the skills and knowledge needed to effectively utilize AR/VR technologies in their teaching.
4. Collaborative networks: Establishment of collaborative networks among healthcare education institutions to share resources, best practices, and research findings related to AR/VR implementation.
5. Industry partnerships: Foster partnerships between healthcare education institutions and AR/VR technology developers to ensure that educational needs drive technological innovation.
6. Ethical guidelines: Develop and implement clear ethical guidelines for the use of AR/VR in healthcare education, addressing issues such as patient privacy and student well-being.
7. Continuous evaluation: Implement ongoing evaluation processes to assess the effectiveness of AR/VR integration and inform continuous improvement efforts.
8. Global outreach: Explore opportunities for international collaboration and knowledge sharing to extend the benefits of this research beyond Australasia.

These recommendations, informed by the comprehensive research undertaken in this project, provide a roadmap for the successful integration of AR and VR technologies in healthcare education. By following these guidelines, institutions can harness the power of immersive technologies to enhance the quality of healthcare education and, ultimately, improve patient care outcomes.

References

Aiello, S., Cochrane, T., & Sevigny, C. (2023). The affordances of clinical simulation immersive technology within healthcare education: a scoping review. *Virtual Reality*. https://doi.org/10.1007/s10055-022-00745-0

Barsom, E. Z., Graafland, M., & Schijven, M. P. (2016). Systematic review on the effectiveness of augmented reality applications in medical training. *Surgical endoscopy*, 30(10), 4174–4183. https://doi.org/10.1007/s00464-016-4800-6

Bruner, J. S. (1966). Toward a theory of instruction. Harvard University Press.

Cook, D. A., Hatala, R., Brydges, R., Zendejas, B., Szostek, J. H., Wang, A. T., Erwin, P. J., & Hamstra, S. J. (2011). Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. *JAMA*, 306(9), 978–988. https://doi.org/10.1001/jama.2011.1234

Dalgarno, B. and Lee, M. (2010) What Are the Learning Affordances of 3_D Virtual Environments? *British Journal of Educational Technology*, 41, 10-32. https://doi.org/10.1111/j.1467-8535.2009.01038.x

Dhar E, Upadhyay U, Huang Y, et al. A scoping review to assess the effects of virtual reality in medical education and clinical care. *DIGITAL HEALTH*. 2023;9. https://doi.org/10.1177/20552076231158022

Doğan, E., & Şahin, Y. L. (2024). Virtual reality environment in pharmacy education: A cyclical study on instructional design principles. *Journal of Computer Assisted Learning*, 40(1), 269–287. https://doi.org/10.1111/jcal.12878

Doig M, Bidner A, Dizon J, Guerrero K, Bezak E, Parange N. Availability and use of antenatal point-of-care ultrasound services within rural South Australian health care. *Aust J Rural Health*. 2022; 30: 281–285. https://doi.org/10.1111/ajr.12811

Drysdale, K., Creagh, N. S., Nightingale, C., Whop, L. J., & Kelly-Hanku, A. (2024). Inclusive language in health policy – a timely case (study) of cervical screening in Australia. *Health Sociology Review*, 1–17. https://doi.org/10.1080/14461242.2024.2356868

Fowler, C. (2015), Learning activities in 3-D virtual worlds. *Br J Educ Technol*, 46: 412-422. https://doi.org/10.1111/bjet.12135

Herrington, J., & Herrington, A. (2006). Authentic learning environments in higher education. *IGI Global*. https://doi.org/10.4018/978-1-59140-594-8

Hodges B. (2003). Validity and the OSCE. *Medical Teacher*, 25(3), 250–254. https://doi.org/10.1080/0142159031000100283 6

Huang, H.-M., Rauch, U., & Liaw, S.-S. (2010). Investigating learners' attitudes toward virtual reality learning environments: Based on a constructivist approach. In *Computers and Education* (Vol. 55, Issue 3, pp. 1171–1182). Elsevier BV. https://doi.org/10.1016/j.compedu.2010.05.014

Kyaw, B. M., Saxena, N., Posadzki, P., Vseteckova, J., Nikolaou, C. K., George, P. P., Divakar, U., Masiello, I., Kononowicz, A. A., Zary, N., & Tudor Car, L. (2019). Virtual Reality for Health Professions Education: Systematic Review and Meta-Analysis by the Digital Health Education Collaboration. In *Journal of Medical Internet Research* (Vol. 21, Issue 1, p. e12959). JMIR Publications Inc. https://doi.org/10.2196/12959

McKenney, S., & Reeves, T. C. (2021). Educational design research: Portraying, conducting, and enhancing productive scholarship. *Medical Education*, 55(1), 82–92. https://doi.org/10.1111/medu.14280

Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. In *Computers and Education* (Vol. 70, pp. 29–40). Elsevier BV. https://doi.org/10.1016/j.compedu.2013.07.033

Moro, C., Štromberga, Z., Raikos, A., & Stirling, A. (2017). The effectiveness of virtual and augmented reality in health sciences and medical anatomy. *Anatomical Sciences Education*, 10(6), 549–559. https://doi.org/10.1002/ase.1696

Paterson, C., Roberts, C., Blackburn, J., Jojo, N., Northam, H. L., Wallis, E., Hind, A., Caulfield, R., Barratt, M., Toohey, K., Kavanagh, P. S., Bacon, R., & Wilson, R. L. (2024). Understanding the needs and preferences for cancer care among First Nations people: An integrative review. *Journal of Advanced Nursing*, 80, 1776–1812. https://doi.org/10.1111/jan.15968

Rushforth H. E. (2007). Objective structured clinical examination (OSCE): review of literature and implications for nursing education. *Nurse Education Today*, 27(5), 481–490. https://doi.org/10.1016/j.nedt.2006.08.009

Seymour, N. E., Gallagher, A. G., Roman, S. A., O'Brien, M. K., Bansal, V. K., Andersen, D. K., & Satava, R. M. (2002). Virtual reality training improves operating room performance: results of a randomized, double-

blinded study. *Annals of Surgery*, 236(4), 458–464. https://doi.org/10.1097/00000658-200210000-00008

Taylor, E.V., Lalovic, A. & Thompson, S.C. Beyond enrolments: a systematic review exploring the factors affecting the retention of Aboriginal and Torres Strait Islander health students in the tertiary education system. *Int J Equity Health* 18, 136 (2019). https://doi.org/10.1186/s12939-019-1038-7

Trankle, S. A., Usherwood, T., Abbott, P., Roberts, M., Crampton, M., Girgis, C. M., Riskallah, J., Chang, Y., Saini, J., & Reath, J. (2019). Integrating health care in Australia: a qualitative evaluation. *BMC Health Services Research,* 19(1), 954. https://doi.org/10.1186/s12913-019-4780-z

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. *Harvard University Press.*

Akhtar, M.H., Cochrane, T., & Anderson, M. (2024). Designing Immersive Reality Environments in Healthcare Education: A Proposed Research Framework. In T. Cochrane, V. Narayan, E. Bone, C. Deneen, M. Saligari, K. Tregloan, & R. Vanderburg. (Eds.), *Navigating the Terrain: Emerging frontiers in learning spaces, pedagogies, and technologies*. Proceedings ASCILITE 2024. Melbourne (pp. 202-212). https://doi.org/10.14742/apubs.2024.1393

Note: All published papers are refereed, having undergone a double-blind peer-review process.