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Original Research

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A Systematic Overview of Reviews of the Use of Immersive Virtual Reality in Higher Education

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Abstract

Objectives: Immersive virtual reality (IVR) provides opportunities to learn within a nonphysical, digital world. The purpose of this critical review was to examine published systematic reviews regarding the benefits and challenges of IVR in higher education to inform best practices.

Method: We followed the Preferred Reporting Items for Overviews of Reviews (PRIOR) to ensure transparency and to afford an evidence-based approach for synthesizing insights from a broad range of research. We analyzed and synthesized 10 reviews that include 332 studies with over 9,878 participants, following an integrated synthesis design process using thematic analysis and emergent coding.

Results: Results confirmed the various benefits and challenges of IVR. The benefits include improved student learning and behaviours, while challenges include technology issues, behaviours that inhibit learning, and learning how to use IVR.

Conclusions: IVR holds considerable potential in disciplines requiring practical applications such as simulation-based training and testing. However, further research into contexts such as participant age, gender, instructional design or learning theory, and longitudinal study is required. Finally, higher education stakeholders will benefit from budgeting time and costs, aligning IVR use with real-world applications, maintaining an adaptive mindset, and developing scaffolded instructional design.

Implications for Theory and/or Practice: The primary benefits of student learning through IVR include enhanced skill acquisition, experiences, and learning outcomes. In addition, while immersive platforms housed in static rooms may present financial challenges, the emergence of—and increased investment into—untethered headsets and haptic controllers can reduce operational costs and increase student access to high-quality learning experiences.

Keywords: *virtual reality, higher education, university, teaching, edtech, literature review*

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Introduction

Digital technology is impacting higher education through its ability to provide unique experiences. This review article examines immersive virtual reality (IVR), one of the more popular forms of alternative digital reality technologies in higher education (Jiawei & Mokman, 2023; Taştan & Tong, 2023). IVR affords users the "perception of being physically present in a nonphysical world" (Freina & Ott, 2015, p. 2). At the same time, virtual reality is "the sum of the hardware and software systems that seek to perfect an all-inclusive, sensory illusion of being present in another environment" (Biocca & Delaney, 1995, p. 63). There are varying levels of immersion in IVR, including low (i.e., phone-based), medium (i.e., cave or room based), and high (i.e., standalone headsets; Taştan & Tong, 2023). This often consists of haptic components that provide tactile stimulation through interaction with embedded digital objects (Moussa et al., 2022).

To engage in IVR, the user requires a platform—the virtual environment consisting of hardware and software used to run other software applications (National Institute of Standards and Technology, n.d.)—and the associated equipment artifacts. Established IVR platforms include Oculus© (Meta), Vive© (High Tech Computer Corporation [HTC]), and Playstation VR© (Sony; Clement, 2022). On average, popular baseline platforms cost US$430 per unit; however, many higher-quality devices cost around US$1,500 (Alsop, 2022; Greenwald, 2022). Equipment artifacts of an IVR platform often include a headset and controllers, although many extensions, such as omnidirectional treadmills, exist (Robertson, 2020). In its current form, the headset typically houses components such as speakers, internet connection, and visual stimulation (Mystakidis et al., 2021). Some headsets are tethered to a hub, such as those for the PlayStation VR, while others, like Oculus, are cable-free. The primary extension is often a pair of handheld controllers that house haptic technology; however, newer equipment, such as wrist-based controllers, is being investigated (Stein, 2022).

While research on the use of IVR in higher education has been going on for decades, interest in and use of VR have increased notably since 2016 (González-Zamar & Abad-Segura, 2020). This significant growth is due primarily to the investment of technology juggernauts like Apple, Meta, Microsoft, and Sony, who are committed to improving hardware and decreasing cost barriers while also streamlining accessories that will enhance the user experience. Estimated annual global sales growth rate is expected to be 8.34% yearly through 2028, leading to a nearly US$400-billion industry (Alsop, 2023; Statista, 2023; Stein, 2022). The associated popularity of IVR in higher education has brought about numerous articles in diverse fields of study, resulting in several systematic reviews. Our overview of the research, including systematic reviews, seeks to bring together diverse insights to guide future use and research.

Purpose of the Study

With the growing interest in and use of IVR in higher education learning environments, we sought to explore and synthesize evidence of its use and effectiveness to inform future evidence-based teaching practices. To achieve our research objective, we conducted an overview of reviews to systematically discover, extract data from, and present the results outlined in thematically related systematic reviews (Gates et al., 2022; Pollock et al., 2019). Our overview explores the same intervention, IVR, for different fields of study to offer a comprehensive synthesis of evidence (Ballard & Montgomery, 2016). We used the *population*, *exposure*, *outcome* (PEO) framework to outline the research objective, as the framework acts to guide the development of answerable questions regarding the evidence of key concepts in systematic reviews (Bettany-Saltikov, 2016; Moola et al., 2015; Pollock & Berge, 2018). Our objective, then, was to inform evidence-based teaching practices of the benefits and challenges (outcome) of using IVR (exposure) in higher education (population).

Method

Our review follows the *Preferred Reporting Items for Overviews of Reviews* (PRIOR; Gates et al., 2022) and focuses on IVR in higher education. The PRIOR framework ensures that the reported findings from existing reviews are clear and transparent (Gates et al., 2022). Guided by PRIOR, our review findings follow three primary steps: First, we outline the search process. Second, we articulate the applied review article inclusion criteria. Then, following article selection, we outline the integrated mixed-method approach to synthesize the results and build a breadth of insights while minimizing methodological differences (Sandelowski et al., 2006). Following the completion of van der Steen et al.'s (2018; 2019) taxonomy of bias determinants, the authors report low potential bias associated with commonly cited issues, including a focus on preferred findings or conflicts of interest.

Frameworks Guiding the Methodology

Preferred Reporting Items for Overviews of Reviews

To ensure transparency in this overview of reviews, we used the PRIOR framework (Gates et al., 2022), which affords an evidence-based approach for synthesizing findings from several literature reviews. Since 2000, there has been a significant increase in systematic overview publications and a rapid increase since 2017 (Bougioukas et al., 2021). However, until PRIOR, there were no explicit guidelines for overview studies that accounted for unique challenges, such as data overlaps (e.g., where the same article appears in more than one review and where the overlapping reviews had the same focus), which could inadvertently bias findings (Gates et al., 2022). With a focus on addressing the reporting gap, the PRIOR framework builds on established systematic evidence- and agreement-based reporting guidelines to outline an overview of previous reviews (Pollock et al., 2019).

Four-Item Risk of Bias in Overviews of Reviews

To support article quality and validity, we followed Ballard and Montgomery's (2017) four-item risk of bias in overviews of reviews. The conditions in the four-item checklist include limited overlap, alignment with our overview's scope, high methodological quality, and being up to date at the time of publication (Ballard & Montgomery, 2017).

Limited Overlap

Findings overlap within a systematic overview is likely to occur when the included articles ask the same research question or have the same objective, which can result in using the same source articles (Ballard & Montgomery, 2017). The threat to validity occurs as some findings will co-occur, which can alter the effect or study outcome. To address the risk of overlap, we included only articles that focused on different fields of study, presented findings from different periods, or had different objectives. Where potential overlap existed, we explored the article included within the potential reviews to ensure there were limited or no duplicates, leading to precise findings (Ballard & Montgomery, 2017).

Alignment With Overview Scope

When the included articles do not provide data or outcomes that align precisely with the guiding question or overview objective, the outcome can relay irrelevant results (Ballard & Montgomery, 2017). For example, a systematic review that amalgamates findings from K–12 and higher education simultaneously can present data that is incongruent with the overview objective, resulting in false outcomes. Following this insight and to limit potential study bias, we sought and included only articles that outlined findings focusing on higher education and that presented the context of learning outcomes and teaching practices that could inform future educators.

High Methodological Quality

Ballard and Montgomery (2017) proposed that ensuring high methodological quality is important; however, the process is nuanced and can differ by review. For instance, methodology and reporting standards can vary by discipline. To ensure the review articles included in this study were of moderate to high quality, we followed Oluwatayo's (2012) criteria for education research in the final article screening stage. These include clearly defined research objectives, applicable demographic insight, transparent methodology, and *a detailed outline of the findings*.

Up-to-Date Articles

Ballard and Montgomery (2017) propose that reviews should include up-to-date information at the time of publication to limit selective oversight in article findings. The reasoning is that new evidence can present differing conclusions or introduce unique variables such as societal changes or geography. To address this risk, the findings presented in this overview include reviews published up to 2023, the year of this review's submission. Additionally, our section entitled Further Insights speaks briefly regarding recent individual articles.

Literature Search

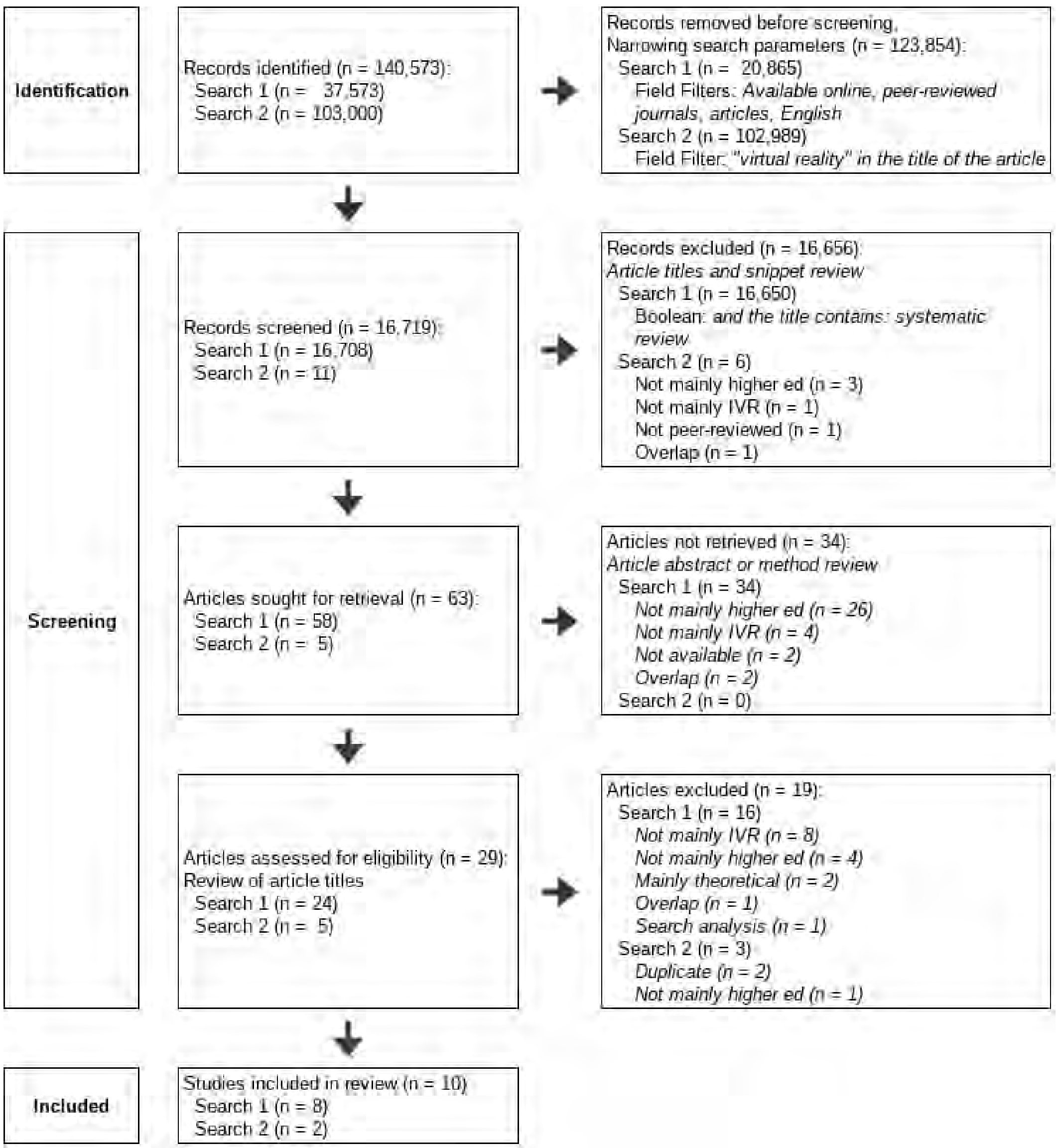
We conducted two systematic searches focusing on exploring the current state of IVR in higher education, using the search term "virtual reality higher education systematic review," which ultimately yielded ten articles for this review. The first search occurred through the institutionally licensed OMNI Search tool. OMNI employs Ex Libris's Alma library software system and the Primo VE discovery system to streamline comprehensive searches of institutionally licensed databases (Sabina, 2019). The first search terms yielded 37,573 records in July 2023 from licensed databases, including ABI/INFORM Complete, Academic Search Premier, CINAHL Complete, DOAJ, EBSCO, IEEE Xplore, JSTOR, PLOS, PsycINFO, and ScienceDirect. The second search was conducted through Google Scholar in the same month to discover articles that may not have yet been indexed under academic licensing. This search resulted in the initial identification of 103,000 review articles. To refine the results from each search's initial identified records, we systematically followed the search flow process outlined in the PRIOR flow diagram (Figure 1), yielding ten review articles included in this overview of reviews. Both searches follow the same steps guided by PRIOR; however, as the two academic search resources follow different filtering processes, each is outlined separately.

For the first search, we applied the field filters "available online," "peer-reviewed journals," "articles," and "English language," which removed 20,865 records. To start the screening process, we sought to refine the search further and applied the Boolean filter, "and the title contains: systematic review," resulting in the removal of another 16,650 records. We used the filter term, as systematic reviews should identify themselves as such in their title (Page et al., 2021). In the next screening phase, we reviewed the article abstracts of 58 records, leading to the removal of 34, as they did not align with the scope of this review. In the final screening phase, we retrieved and assessed 24 articles; however, only eight met the scope of this study. The primary exclusion reason was that the studies did not present articulated findings of the use of IVR (n = 8 articles), followed by studies that did not present delineated findings from higher education (n = 4). The other four removed articles included those that were theoretical (n = 2), showed review overlap (n = 1), and had an absence of educational outcomes (n = 1).

To first refine the second search, we used the Boolean filter "and the title contains: virtual reality," resulting in 11 records for further consideration. Following a review of the abstracts for the remaining records, six were excluded as they did not align with the scope of this review. Five articles were retrieved and thoroughly assessed for eligibility, resulting in three excluded studies as two were duplicates and one did not primarily focus on higher education. Figure 1 outlines the search flow for searches one and two.

Articles considered to be within the scope of this overview of reviews present findings from empirical studies with a primary focus on using IVR in higher education: college, university, tertiary, or level-three institutions. Beyond the criteria outlined in the literature search, the ten reviews included in this review were screened for and largely met specific criteria to ensure that our overview provides transparent, high-quality insight by addressing common quality challenges in educational research. The criteria include clearly defined research objectives, applicable demographic insight, transparent methodology, and a detailed outline of the findings (Oluwatayo, 2012). Each selected article provided moderate to high insight into the research criteria. Additionally, 80% (*n* = 8 articles) of the articles included in this overview were published in journals with an index of Q1 or Q2, while another was Q4, as SJR (n.d.) outlined in August 2023. Findings from a meta-epidemiological study by Heidenreich et al. (2023) indicate that articles published in higher-ranked journals can serve as an additional quality check as they provide a limited but positive correlation with study accuracy.

Figure 1. *PRIOR Flow Diagram*



Note. Adapted from Gates et al., 2022.

Analysis and Coding

Our review follows a mixed research analysis and synthesis approach to integrate the results from qualitative, quantitative, and mixed-method studies, in order to direct practice and future research through a summary of knowns and unknowns about a target phenomenon (Sandelowski et al., 2006, 2011, 2013). Specifically, we use an integrated mixed research design, which Sandelowski et al. (2006) define as the assimilation—rather than configuration—of findings produced from different research methods to extend existing research that addresses a target phenomenon or objective. The dynamic analysis process is achieved by transforming findings to afford their combination (Sandelowski et al., 2011). For example, we converted qualitative findings into quantitative forms to outline quantitative elements, such as in the context section of this study. Also, quantitative findings are converted into qualitative forms to address the benefits and challenges of using IVR in higher education. The analysis followed four steps, the first three of which summarize the research context, while the fourth, an integrated synthesis, involved collecting and transforming the findings in four phases.

The first analysis step involved gathering methodological insight, including defined research objectives, applicable demographic insight, transparent methodology, and a detailed findings outline. Next, we collected descriptive context from the reviews, including the source database, journal resource, article title, purpose, sample size, articles included in the review, and publication dates. The third step involved summarizing the demographic variables, including geography, sample size, gender, age, and subject area. The three steps provided a descriptive context for the research articles reviewed.

The fourth step is an integrated synthesis that starts with deductive coding guided by the research purpose, while a four-phase thematic analysis was used to develop themes through emergent coding (Popay et al., 2006; Sandelowski et al., 2006; Thornberg & Charmaz, 2014). In the first phase, we explored relationships between study characteristics to determine themes. For phase two, we assessed the robustness of emergent theme quality and quantity through concept mapping, outlined below (Popay et al., 2006). The third and fourth phases replicated phases one and two to determine the three primary themes.

The mapping process involved developing scaffolded online spreadsheet tables, hosted on institutionally licensed platforms with multi-stage authentication, containing the extracted review contexts and findings. Online spreadsheets allow for easily accessible collaborative capabilities that serve as efficient and customizable tools for storing and locating data (Creswell, 2015). Through the scaffolded tables, we identified and linked patterns and variables through conceptual triangulation to determine potential codes and emergent themes (Popay et al., 2006). Interrater reliability was established during the mapping phase, initiated by using the research purpose to provide the *a priori* codes, while the authors generated the emergent or open codes. Open codes were individually developed by navigating back and forth between the findings and codes to develop, merge, remove, and refine codes in order to achieve interrater agreement (Cole, 2023).

Results

We first present the overall context of the review articles, followed by the benefits and challenges of using IVR. Table 1 presents a summary of the ten articles included in this overview of reviews.

Table 1. *Description of Literature Reviews*

Citation	Database	Resource	Title	Purpose	Sample size	Articles	Publication dates
Christian et al. (2021)	DOAJ	*International Journal on Informatics Visualization* (Q4)	Virtual Reality (VR) in Superior Education Distance Learning: A Systematic Literature Review	To identify advances in superior education through VR technologies during 2016–2021.		27	2016–2021
Lui et al. (2023)	Springer	*Journal of Science Education and Technology* (Q1)	Theory-Based Learning Design With Immersive Virtual Reality in Science Education: A Systematic Review	To outline the state of IVR application in science education and develop guidelines to optimize student learning outcomes.	2609	29	2013–2022
Moussa et al. (2022)	PubMed	*European Journal of Dentistry* (Q1)	Effectiveness Of Virtual Reality and Interactive Simulators on Dental Education Outcomes: A Systematic Review	To determine the implications of VR on the learning outcomes of dental education and student attitudes towards it.	5275	73	2010–2021
Mystakidis et al. (2021)	MDPI	*Applied Sciences* (Q2)	Deep And Meaningful E-Learning With Social Virtual Reality Environments in Higher Education: A Systematic Literature Review	To assess the relationship between social virtual reality environments and deep, meaningful learning for distance learning.		33	2004–2019
Özyurt et al. (2021)	DOAJ	*Journal of Pedagogical Research* (NR)	A Systematic Review and Mapping of the Literature of Virtual Reality Studies in Earth Science Engineering Education	To outline the literature and provide insight regarding the relationship between VR applications and earth sciences engineering education.	86	7	2008–2020
Plotzky et al. (2021)	Elsevier	*Nurse Education Today* (Q1)	Virtual Reality Simulations in Nurse Education: A Systematic Mapping Review	To scope the insights of the use of educational VR nursing simulations and to analyse didactic and technical approaches.	788	22	2014–2020
Radianti et al. (2020)	Elsevier	*Computers and Education* (Q1)	A Systematic Review of Immersive Virtual Reality Applications for Higher Education: Design Elements, Lessons Learned, and Research Agenda	To explore the role of immersive VR in higher education.		38	2016–2018
Sadek et al. (2023)	ACGME	*Journal of Graduate Medical Education* (Q2)	Impact of Virtual and Augmented Reality on Quality of Medical Education During the COVID-19 Pandemic: A Systematic Review	To provide a quantitative narrative synthesis of immersive technologies used during the COVID-19 pandemic for medical education.		13	2020–2022

Citation	Database	Resource	Title	Purpose	Sample size	Articles	Publication dates
Taştan & Tong (2023)	Wiley	*Computer Applications in Engineering Education* (Q2)	Immersive Virtual Reality in AECO/FM to Enhance Education: Systematic Literature Review and Future Directions	To present insight into the impact of IVR application in architecture, engineering, construction, operation, and facility management.	398	79	2013–2022
Xu et al. (2021)	Frontiers	*Frontiers in Virtual Reality* (NR)	HMD-Based Virtual and Augmented Reality in Medical Education: A Systematic Review	To evaluate the effectiveness of VR or AR in medical education and training.	722	11	2007–2020
Total					9878	332	

Context

Research Scope

Six studies reference 9,878 participants (Range = 86–5275) at multiple levels of tertiary education (Lui et al., 2023; Moussa et al., 2022; Özyurt et al., 2021; Plotzky et al., 2021; Taştan & Tong, 2023; Xu et al., 2021), while four studies did not indicate the total number of participants (Christian et al., 2021; Mystakidis et al., 2021; Radianti et al., 2020; Sadek et al., 2023).

Table 2 shows that the reviews provide insights from more than six listed fields of study, of which the most researched was applied science (*n* = 181, 56% of studies). This was followed in decreasing order by the multidisciplinary fields of architecture, engineering, construction, operation, and facility management (AECO/FM) (*n* = 79, 24%); natural science (*n* = 26, 8%); humanities (*n* = 14, 4%); education (*n* = 10, 3%); and computer science (*n* = 10, 3%). Within applied science, medical studies were the most frequently identified fields (*n* = 128 articles, 71%), of which dentistry (*n* = 81, 63%) and nursing (*n* = 24, 19%) were the most researched, often considering simulation-based activities.

Table 2. *Fields of Study*

Citation	Applied Science	AECO/FM	Natural Science	Humanities & Social Science	Education	Formal & Computer Science	Other
Christian et al. (2021)	12		8	3	5		
Lui et al. (2023)	23		4	1			
Moussa et al. (2022)	73						
Mystakidis et al. (2021)	5		6	5	5	5	
Özyurt et al. (2021)	7						
Plotzky et al. (2021)	22						
Radianti et al. (2020)	15		8	5		5	5
Sadek et al. (2023)	13						
Taştan & Tong (2023)		79					
Xu et al. (2021)	11						
TOTAL	181	79	26	14	10	10	5

Country

Five reviews (Christian et al., 2021; Lui et al., 2023; Moussa et al., 2022; Özyurt et al., 2021; Plotzky et al., 2021) provided insights from 30 countries. The highest number of articles references in the reviews originated in the United States (*n* = 55, 32%), followed by the United Kingdom (*n* = 22, 13%), China (*n* = 20, 11%), Australia (*n* = 9, 5%), Germany (*n* = 9, 5%), Denmark (*n* = 8, 5%), Japan (*n* = 7, 4%), and the Netherlands (*n* = 5, 3%). Table 3 provides context for the top eight countries.

Table 3. *Countries*

Citation	USA	UK	China	Aus	Germany	Denmark	Japan	NL	Other*
Christian et al. (2021)	8	2	5	1			2		9
Lui et al. (2023)	14	1	2	1		7		1	2
Moussa et al. (2022)	14	11	7	4	4		3	4	17
Özyurt et al. (2021)	5		6	3	3				
Plotzky et al. (2021)	6	3			1	1	2		9
Sadek et al. (2023)	8	5			1				2
Total	55	22	20	9	9	8	7	5	39

**Note*: Saudi Arabia, Thailand, and Turkey (*n* = 4 articles each); Brazil and France (*n* = 3); Belgium and Ecuador (*n* = 2); Austria, Canada, Denmark, Greece, Hong Kong, Hungary, India, Korea, Malaysia, Norway, Russia, Switzerland, Taiwan, and Spain (*n* = 1).

Platforms

Four out of ten reviews described the IVR platforms used in 94 studies (Christian et al., 2021; Liu et al., 2023; Plotzky et al., 2021; Xu et al., 2021). Key platforms identified include Oculus (*n* = 21, 22%), Vive (*n* = 17, 18%), Desktop VR (*n* = 8, 9%), Google Cardboard (*n* = 7, 7%), Samsung Gear (*n* = 5, 5%) and Windows MR (*n* = 1, 1%).

Themes

We sought to articulate the benefits and challenges of IVR in higher education to inform best practices. The benefits category revealed two themes. The first is improved student learning, which contains the subthemes skill acquisition, experience, and learning outcomes. The second theme is student behaviours that support learning. Three themes emerged from the challenge category: technology issues, learning how to use IVR technology, and behaviours that inhibit learning. The technology issues theme contains the subthemes equipment, cost, generalizability, and VR sickness.

Benefits of IVR

Nine reviews articulated the benefits of using IVR in higher education. The two primary benefits are improved student learning (*n* = 9 reviews) and student behaviours that support learning (*n* = 6 reviews). Subthemes within the first theme include skill acquisition (*n* = 8 reviews), experience (*n* = 7 reviews), and learning outcomes (*n* = 4 reviews).

Improved Student Learning

Nine reviews addressed how IVR in higher education can enhance learning, with three subthemes emerging: skill acquisition, experience, and learning outcomes. Skill acquisition refers to the refined ability to perform tasks (Lui et al., 2023; Moussa et al., 2022; Mystakidis et al., 2021; Özyurt et al., 2021; Plotzky et al., 2021; Sadek et al., 2023; Taştan & Tong, 2023; Xu et al., 2021), whereas student experiences refers broadly to how the student engages with information (Christian et al., 2021; Lui et al., 2023; Özyurt et al., 2021; Plotzky et al., 2021; Sadek et al., 2023; Taştan & Tong, 2023; Xu et al., 2021). Finally, learning outcomes pertains to the development of student insight and knowledge (Lui et al., 2023; Mystakidis et al., 2021; Moussa et al., 2022; Xu et al., 2021).

Skill Acquisition

IVR provides diverse opportunities to develop the requisite skills required for various fields of study and practice (*n* = 8 reviews). Given the limited diffusion of IVR technologies at this time, students are often required to learn new digital skills to use the technology; however, there are also opportunities to improve those needed for digital rendering and virtual presentation (Mystakidis et al., 2021; Taştan & Tong, 2023). Looking at various disciplines, Liu et al. (2023) found that virtual labs can enhance practical lab skills. Similarly, Özyurt et al. (2021) showed that immersive simulations can enhance the skill training of non-experts in earth sciences, through such opportunities as virtual three-dimensional topography. Exploring diverse disciplines, including applied sciences, natural science, humanities and social science, education, and formal and computer science, Mystakidis et al. (2021) found evidence that students using IVR experienced improved cognitive skills, such as procedural, higher-order thinking and problem-solving.

Procedural skills were also prominent in medical-based learning. Moussa et al. (2022) reported that training dental students using IVR significantly enhanced manual skills, even during short training periods. IVR paired with haptic technology turned out to be an efficient method of improving accuracy, hand-eye coordination, and spatial reasoning skills in the early stages of professional development. In developing nursing students' procedural training, IVR helped cultivate emergency responsiveness, along with interpersonal and psychomotor skills (Plotzky et al., 2021). In terms of medical skills, IVR enhanced learning efficiency, potentially through increased access to hands-on experiences with reduced consequences, as well as the ability to refine skills (Sadek et al., 2023; Xu et al., 2021).

Experience
Seven reviews found improvements to student learning through their experience with IVR. Two studies that focused on earth science engineering and nursing, respectively, (Özyurt et al., 2021; Plotzky et al., 2021) indicated that IVR was often a fun way to learn in a safe and user-friendly environment. Furthermore, IVR is considered an enjoyable simulation-based learning method that can improve content engagement and feedback experiences (Lui et al., 2023; Özyurt et al., 2021; Plotzky et al., 2021; Sadek et al., 2023). From their science-focused review, Lui et al. (2023) found that providing foundational knowledge and pre-training tasks is a critical consideration for enhancing the learning experience with IVR. Specifically, providing students with the context for what is to be learned and providing foundational knowledge for using the virtual environment resulted in improved engagement through a reduction in distractions.

Using VR for learning simulation also can be cost-effective and reduce risk. Visualizing concepts—such as architectural or geographic entities—without needing to have access to building materials or needing to travel and physically experience the subject reduces potential education costs (Christian et al., 2021; Özyurt et al., 2021; Taştan & Tong, 2023). While the current costs of developing IVR are too expensive for some situations, using preexisting content, such as simulated geography-based walk-arounds (e.g., site visits) or surgeries, is often more cost-effective than the current options (Taştan & Tong, 2023; Xu et al., 2021). Additionally, using IVR in medical education affords students the opportunity to develop and enhance skills required to deal with challenging scenarios while limiting their exposure to negative or potentially harmful experiences, such as surgical error (Sadek et al., 2023; Xu et al., 2021). Taştan and Tong (2023) outlined similar findings for AECO/FM simulations.

Learning Outcomes
IVR can enhance formative and summative learning outcomes in various disciplines (*n* = 4 reviews). Most of the fields of study examined by Mystakidis et al. (2021) reflected positive gains in multiple learning domains including cognitive, social, and affective. Specifically, students experienced significant improvements in graded learning performance (cognitive), collaborative learning activities (social), and perceived learning satisfaction (affective). Similarly, Moussa et al. (2022) found that learning through IVR positively improved dental students' theoretical knowledge retention. Focusing on medical education students—including first-year students, surgical trainees, and nursing interns—Xu et al. (2021) found equal or better outcomes through virtual environments when compared to traditional learning environments. Building on the capacity of pre-training to enhance experience, Lui et al. (2023) propose that pre-training and IVR can also significantly improve learning outcomes in the context of knowledge retention, in both short- and long-term self-efficacy.

Student Behaviours That Support Learning
Two primary benefits of IVR related to behaviors supporting learning *(n* = 6 reviews) include decreased negative stress states (Moussa et al., 2022; Mystakidis et al., 2021; Sadek et al., 2023) and increased motivation for learning (Lui et al., 2023; Mystakidis et al., 2021; Taştan & Tong, 2023; Xu et al., 2021). Studying the use of IVR with a haptic response for training dental students, Moussa et al. (2022) found that the ability to practice foundational skills in a simulated environment helped reduce anxiety associated with the management and treatment of real-life patients, through improved self-perception of competence; Sadek et al. (2023) found comparable results for medical training. Reflecting on learning experiences by students enrolled in diverse fields of study (applied science, computer science, education, engineering, natural science, and social science), Mystakidis et al. (2021) observed that IVR avatar-mediated experiences helped enhance learner self-efficacy and motivation. Furthermore, studies focused on AECO/FM, medical education, and general science education also found increased learner motivation through IVR learning experiences (Lui et al., 2023; Taştan & Tong, 2023; Xu et al., 2021), specifically through learner agency and control, as students appreciated the ability to direct their learning experiences, such as movement, interactivity with artifacts, learning focus, and learning pace.

Challenges for Implementing IVR

Three themes reflecting challenges emerged from nine reviews. The first theme, technology issues (*n* = 9 reviews), contains four subthemes: equipment (*n* = 8 reviews), cost (*n* = 4 reviews), generalizability (*n* = 4 reviews), and VR sickness (*n* = 4 reviews). The other two primary themes are learning how to use IVR technology (*n* = 4 reviews) and behaviours that inhibit learning (*n* = 3 reviews).

Technological Issues

Nine articles identified four technology-related challenges associated with the use of IVR in higher education, including equipment (*n* = 8 reviews), cost (*n* = 4 reviews), generalizability (*n* = 4 reviews), and VR sickness (*n* = 4 reviews).

Equipment

An analysis of eight reviews revealed that equipment considerations could inhibit IVR use. Problems such as internet connection and hardware or software issues can negatively affect the learning process (Christian et al., 2021; Sadek et al., 2023). Also, realism may be an issue, as it is not always possible for IVR to adequately reflect human or environmental responses (Moussa et al., 2022; Plotzky et al., 2021; Taştan & Tong, 2023). For example, cables attached to devices can inhibit immersive feel and experience (Radianti et al., 2020; Taştan & Tong, 2023), and image quality needs to be high, as poor image quality can inhibit the perception of immersion (Özyurt et al., 2021; Taştan & Tong, 2023). Next, some study areas, such as dentistry, may use specialized equipment, limiting the impact of IVR to on-campus learning scenarios (Moussa et al., 2022). Lastly, with privacy and security concerns associated with different platforms or programs, some institutions may find it difficult to get authorization for use in academic settings (Mystakidis et al., 2021).

Cost

Four reviews reported that equipment and program costs could be challenging when using IVR. Three studies (7%) in Christian et al.'s (2021) review indicated that the budget for IVR equipment acquisition was a limiting factor for their study and broader implementation. Mystakidis et al. (2021) added that very few studies focused on the cost of implementation, use, or maintenance, thereby overlooking the perspectives and experiences of marginalized populations. The cost of IVR limits the potential for full-class use; consequently, IVR may be best used as a supportive tool rather than a required resource for an entire course (Radianti et al., 2020; Xu et al., 2021).

Generalizability

Based on four reviews, three challenges emerged for the generalizability of IVR. First, the diverse use of applied technologies makes it challenging to determine the generalizability of specific enhancements, such as haptic technology, as it is available for only some platforms (Moussa et al., 2022). Second, it is difficult to determine whether IVR simulation is more effective than a traditional video monitor (Plotzky et al., 2021). Finally, the limited number of high-quality IVR learning experiences for educational use makes it hard to broadly implement and compare (Özyurt et al., 2021; Taştan & Tong, 2023). Limited quality can inhibit perceptions of immersion, limit the training scenarios, and potentially reduce student motivation due to boredom resulting from repetitiveness.

VR Sickness

Four reviews provided findings associated with the phenomenon called VR sickness, which is the sensation of dizziness experienced during VR experiences. While a limited number of students will experience VR sickness, it is not uncommon (Christian et al., 2021; Xu et al., 2021), especially in long-term immersive scenarios (Özyurt et al., 2021). Taştan and Tong (2023) found similar outcomes, even during short-duration experiments focused on health, safety, and occupational tasks. For those prone to VR sickness, their dizziness can be associated with nausea and impaired mental states, inhibiting learning opportunities.

Learning How to Use IVR Technology

Three challenges associated with learning how to use and integrate IVR technology were outlined in four reviews, specifically, challenges associated with educator training, considerations of learning theory, and students' cognitive engagement. Regarding training, educators often require support personnel and training to understand the IVR hardware and software, notably for experimentation and feedback before implementation and for onboarding and training students during implementation (Christian et al., 2021; Mystakidis et al., 2021). As a result, higher education institutions may find challenges associated with the resulting costs and comprehensive planning necessary to achieve readiness. Concerning the integration of VR, Radianti et al. (2020) and Taştan and Tong (2023) found limited consideration of learning theory in many VR studies (*n* = 26, 68% and *n* = 51, 65% respectively). Instead, educators focused on the usability of technology over learning processes or outcomes. Learning theory in the context of IVR refers to the role of feedback, challenge, or philosophical concepts that can inform use practices beyond that of the technical skills required to engage within a virtual environment (Mystakidis et al., 2021). Mystakidis et al. (2021) state that beyond the ability to appreciate novel learning experiences, instructors must ensure that implementing IVR technology is appropriate to supporting intended learning outcomes.

From a student perspective, Lui et al. (2023) found mixed results for students with limited previous VR and digital gaming experiences and the impact of IVR on learning outcomes. The authors found the simultaneous introduction of new learning materials, new IVR, and a requirement to move freely—rather than remaining seated—can lead to students being overwhelmed. Similarly, five articles from Taştan and Tong's (2023) review noted that student cognitive load increased during IVR, potentially related to extended immersion periods. The authors propose that increased cognition may enhance learning; however, it can have adverse impact on vigilance, through fatigue. In light of these findings, educators should be careful in timing the introduction of new elements and materials to reduce negative outcomes associated with cognitive overload and be aware of IVR educational task complexity.

Behaviours That Inhibit Learning

Three reviews revealed two primary challenges regarding learning behaviour: social interaction and note-taking ability. Currently, there are limited opportunities for student peer interaction within IVR environments, which can inhibit social learning interactions (Özyurt et al., 2021; Plotzky et al., 2021; Radianti et al., 2020). In addition, note-taking is an everyday learning activity that is not possible when immersed in VR learning, potentially inhibiting the recording and instantiation of new knowledge and concepts (Özyurt et al., 2021).

Further Insight

With the rapid development and implementation of new digital technologies such as IVR in higher education, updated systematic reviews will be required to address current research limitations and to provide context for more recent tools. For example, a search of the phrase "immersive virtual reality higher education" and the Boolean filters of: "AND Title contains "virtual reality" OR "VR" AND Title contains "higher education" OR "university" or "college" returned 19 peer-reviewed articles published between April 2022 and 2023 that align with our objectives. Following a rapid review, many of the articles express the same outcomes highlighted in this review: student behaviours and perceptions (*n* = 8 articles), conceptual application (*n* = 3), and student learning outcomes (*n* = 1). However, more studies are reflecting on learning theory and education (*n* = 5). Mark and Thomas (2022) provide positive insight into longitudinal IVR use, and a study by Zeng et al. (2022) explores the role of student physical wellness through IVR, indicating new research directions to be addressed by upcoming reviews.

Discussion

Following the increased diffusion of IVR in higher education, we explored and synthesized evidence of the benefits and challenges associated with using IVR in higher education to inform future evidence-based teaching practices. From the ten articles included in this overview of reviews, two primary benefits emerged:

improved student learning—including skill acquisition, experience, and learning outcomes—and student behaviours that support learning. The overview revealed three challenges: technology issues, such as equipment, cost, generalizability, and VR sickness; learning how to use IVR; and behaviours inhibiting learning. The use of IVR in higher education requires further refinement in practice, financial investment, and time in order to become a viable formal learning tool. Still, the potential benefits of IVR—improved student learning experiences and behaviour—appear to justify the time and investment required. An awareness of the challenges can help guide multidisciplinary teams in implementing IVR more effectively in higher education.

Learning Experiences

Three significant benefits of student learning through VR include enhanced learning experiences, positive learning outcomes, and improved skill acquisition. VR learning experiences are considered cost-effective for fun and safe simulation-based experiences (Özyurt et al., 2021; Plotzky et al., 2021; Xu et al., 2021). Similarly, students experience positive learning outcomes in scoring in cognitive domains (Mystakidis et al., 2021; Moussa et al., 2022; Xu et al., 2021). Finally, students can develop and refine manual skills with reduced consequences and a direct transfer to real-world scenarios (Moussa et al., 2022; Plotzky et al., 2021; Xu et al., 2021).

Based on our review, the primary challenges to learning through IVR include the training required for effective use and the limited use of learning theory in existing content. As with any new tool, proper training will help support its effective use. VR appears to be no different, with researchers indicating that support personnel and time for trials of the technology are critical for educators and students (Christian et al., 2021; Mystakidis et al., 2021). The lack of embedded learning theory (Radianti et al., 2020; Taştan & Tong, 2023) could be addressed by including instructional designers in the different stages of software development. Alternatively, if educators have sufficient time to test IVR with targeted content, they can ensure that it supports the curriculum and learning outcomes.

Learning Behaviour

The positive impact of IVR on student learning indicates a reduction in negative stress and an improvement in motivation, while the challenges point to a lack of social connection and reflection strategies. Simulation activities in VR are less likely to result in negative experiences, such as injury or limited access to simulation activities, which appears to reduce student distress (Moussa et al., 2022; Mystakidis et al., 2021). Additionally, the increased opportunity for trial and error supports student motivation to learn and engage (Mystakidis et al., 2021; Xu et al., 2021).

The challenge, however, is that students can feel isolated and disconnected from their peers in VR activities, as many programs afford limited communication outside of the environment (Özyurt et al., 2021; Plotzky et al., 2021; Radianti et al., 2020). Also, students need to remove themselves from immersive environments in order to take notes, which could limit reflective learning strategies (Özyurt et al., 2021). A potential short-term solution to both problems is affording audio channels within a program so that students can talk with their peers and take voice notes.

Limitations and Opportunities for Future Research

We noted four limitations that could offer future opportunities for IVR research. First, the age of participants was not examined in detail. Age could moderate student motivation regarding perceptions of technology use, often with nuance occurring at a generational level (Calvo-Porral et al., 2020; Karadal & Abubakar, 2021; Papp-Zipernovszky et al., 2021). Second, gender differences were not examined in detail (Heidari et al., 2016; Taştan & Tong, 2023). Gender might influence intervention outcomes through underlying societal perceptions of gender, along with physiological responses associated with biological sex. When it comes to IVR, a participant's gender may impact their relationship with technology, or sex may play a role in physical response to virtual environments (e.g., Felnhofer & Kothgassner, 2014). The third limitation is the need for better insight into instructional design from studies outlined by the review—specifically, increased articulation of the teaching and learning approach guiding IVR implementation. Understanding the educational implications of use for the associated instructor and students is essential to understanding IVR's potential in higher education. Finally, longitudinal studies are required for a better understanding of IVR's effectiveness (Moussa et al., 2023; Taştan & Tong, 2023).

Three opportunities for future research include continuing to implement and review simulation-based IVR experiences, education-based sports, and the increased opportunity to support medical training in remote or underfunded regions. First, formal and vocational education programs that benefit from practical simulation-based learning experiences, such as firefighting (Texas Engineering Extension Service [TEEX], 2023), pharmaceuticals (DeWitt, 2023), and medicine (Suvarna, 2022), will benefit from further implementation and more rigorous research. Next, research on IVR for higher education-based sports and performance is limited, and the technology may provide unique opportunities for skill and athletic development (Putranto et al., 2023). Finally, building on Sadek et al.'s (2023) insights from COVID-19 period studies, researchers and administrators may consider how IVR can help develop foundational medical skills for students in remote or underfunded regions.

Conclusion

IVR in higher education is potentially a cost-effective form of educational technology that supports students' skill acquisition, learning outcomes, and motivation-based behaviours. However, optimization requires access to programs with solid levels of realism and awareness of the potential challenges, such as technology-related issues, technology-use skills, and problematic student behaviours. We conclude with brief recommendations for key stakeholders considering implementation.

For higher education stakeholders in charge of financing who are considering the use of IVR, we propose three general recommendations: Administrators and educators should budget for training time, consider how transferable IVR will be to real-world scenarios (e.g., design, medical practice, or mock training scenarios), and be adaptable. Each recommendation will also require a cost analysis, an original review of the IVR platform and program costs, and consideration of how long a platform will be usable before it is replaced. Throughout the process, it is essential to remember that IVR is changing rapidly (Al Dhaheri & Hamade, 2022; Mickle & Chen, 2022; Robertson, 2022). Equipment is becoming less prone to technical difficulties and less cumbersome, and technology companies are pushing to increase accessibility with more streamlined hardware (Robertson, 2022). Therefore, being open-minded and flexible about the shifts in equipment and terminology is critical for supporting student experiences and success in higher education.

Once IVR is approved, educators will want to know the timing, learning outcomes, and potential challenges. Planning time for educator and student training is required to optimize usage time while reducing potential negative stress scenarios. For example, systematically scaffolding new materials, new digital experiences, and self-directed IVR learning opportunities can give students unique opportunities to learn and encode materials. Implementation must focus on learning rather than on the technology itself. Also, programs must ensure that alternative learning opportunities are available before implementation to account for technical, psychological, or physiological barriers that may limit access or reduce the effective implementation of IVR.

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