Brilliant but Bounded: The Limitations and Future Insights of Virtual Reality Applications in Education, Healthcare, and Workplace

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Abstract: With recent technological innovations, Virtual Reality (VR) has transformed from a niche entertainment technology into a pivotal tool, with applications spanning across a wide range of industries, establishing itself as an effective and productive tool, particularly across healthcare, education, and the workplace. This review first examines a series of studies conducted based on the use of VR in enhancing higher education classrooms, promoting empathy learning among English language learners, enabling rare clinical training, treating phantom pain, facilitating effective collaborations, and supporting professional development, with a focus on exploring and recognizing VR's strengths, limitations, and future potential in practical applications. Subsequently, the discussion proceeds to critically analyze the methodological cases, and concludes with a systematic review of the practical limitations and future insights of VR. Through this review, immersive technologies have indicated clear advantages, including safe simulation, enhanced empathy, increased engagement, facilitated independence, less stress, and cost-effectiveness. However, common challenges persist, including accessibility issues, technological limitations, user-friendly designs, and social fragmentation. By comparing these studies, this review suggests pathways for the sustainable and equitable integration of VR, concluding with key questions for future research and implementation that emphasize aligning technological innovation with industrial needs.

1 INTRODUCTION

Virtual Reality (VR), with the maturing technology and public acknowledgement, has navigated itself into the mainstream, being integrated and capitalized on in various industries, particularly education, healthcare, and the workplace. It immerses users in a three-dimensional computer-generated simulation with primarily visual, audio, and haptic tactile elements designed for a particular context. VR has been promised to revolutionize how humans explore areas restricted by accessibility, emulability, and cost, with the expectation of enabling learning, creation, collaboration, and connection.

Education is one of the primary fields of anticipation, with expectations that VR will enable teaching to be more immersive, intuitive, and enduring. It has overcome many issues faced by traditional education, which fall short in promoting diversity, providing limited resources, and offering personalized learning (Mallek et al., 2024). Particularly, VR enables a shared virtual experience that allows classrooms to interact more "tangibly" in a virtual world, fostering empathy by placing users in others' shoes. However, such integration has achieved only limited success, with real-world adoption hindered by cost, usability, and integration challenges.

Healthcare plays a crucial role in the application of VR, introducing its concept, strengths, and prospects to a broader population, thereby enhancing medical training, clinical treatment, and resource allocation (Prajapati & Kumar, 2025). Traditionally, healthcare faces limitations in the form of specialized training, resource allocation, and personalized treatment, which are especially pronounced in rural or underserved areas, where access to specialized care is limited. The integration of VR is pivotal in enabling realistic, accessible, and risk-free environments for

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treatment and training, with a focus on repeatability, cost-effectiveness, precision, and controlled simulation, thereby overcoming the ethical and logistical constraints of real-world procedures. The integration towards this goal offers a promising venue for future development and adaptation.

VR plays a crucial role in the workplace, particularly with its advantages in fostering shared virtual spaces for collaboration, brainstorming, and presentations (Orel, 2022). It streamlines ideation by allowing participants to immerse themselves in the environment, thereby experiencing rather than just imagining or visualizing before concrete development. Conventional training and design methods often fall short in high-risk, experimental, or rapidly changing industries. VR effectively bridges the gap between both end users, in this case, offering a transformative approach that brings the different layers of production together into one, allowing for tighter connections, improved feedback, and reduced costly revisions. As computation and graphic rendering capabilities continue to improve, pushing VR into new domains of realism, the future of VR holds potential for revolutionizing professional and operational efficiency.

This paper examines the development, limitations, and future research implications of various case studies, investigating current constraints to foster more intuitive, context-aware systems that are both flexible and inclusive. If addressed thoughtfully, VR can evolve from a niche innovation into a foundational tool for training, care, and professional collaboration across sectors.

2 REVIEWS

2.1 VR Application in Education

As Virtual Reality becomes more affordable and accessible, voices advocating for experimenting with VR as a tool for immersive and interactive learning have started to emerge. Yet, public awareness and institutional adoption remain limited, revealing a gap between technological promise and practical application. The following sections review existing research to assess the effectiveness, accessibility, and barriers that continue to shape the future role of VR in education.

Several studies have demonstrated the practical impact of VR in education. For example, Hagge (Hagge, 2021), in his 2021 research "Student Perceptions of Semester-Long In-Class Virtual Reality: Effectively Using "Google Earth VR" in a Higher Education Classroom," integrated HTC Vive VR headsets into four face-to-face geography classes over a two-year period, visiting relevant locations for the course. This allowed individuals to use Google Maps VR while others observed mirrored content. Survey results revealed unexpected perceptions from both used and observed students, who reported similar positivity towards classroom VR. The findings raise speculation about how classroom VR, as a social construct, promotes positive reinforcement, prompting the question of whether physical immersion is necessary for both educational and engagement purposes. The mere presence of VR might be enough to encourage active engagement, which hinges on the often problematic cost of full VR classrooms, offloading the resources and money necessary to create a meaningful impact within classrooms. However, many students, approximately 36%, reported anxiety, shyness, and awkwardness with front-of-the-room and technology fears, particularly the use of controls. While VR virtual classes are often seen as the cure for shyness among enthusiasts, the barriers that many overlook can be devastating to students without a technical background. Ultimately, the review encourages VR not to replace traditional education but to complement it by providing an enhanced learning experience.

Focusing on the application of VR in the field of education and empathy, Guan et al. investigate whether an empathetic VR-based learning approach can enhance the writing performance and empathy development of junior high EFL students (Guan et al., 2024). The researchers closely monitored a group of 63 junior high students assigned to either an experimental group using the empathetic VR-based learning (E-VRL) approach or a control group using standard VR-based learning (VRL), followed by assessments of empathy and writing performance. Finally, the statistics demonstrated that E-VRL surpassed VRL in aspects such as cognitive, dialogic empathy, and content. This study highlights promising directions for VR in education, particularly its capability to foster empathy by immersing students in rich, multisensory environments. The author suggests VR is particularly effective for occupations that value emotional intelligence, such as language learning, arts, and social studies. Additionally, VR's ability to engage learners through interactive scenarios enhances creativity and motivation, especially in writing and communication-based tasks. Nevertheless, while the E-VRL implementation shows positive growth among participants, the study also highlights limitations in its

ability to foster long-term empathy and engagement. Emotional empathy may be underdeveloped if the VR content is too neutral or scenic rather than emotionally charged. For instance, the scenery of Jinhua Shuanglong Cave may be more suitable for a picturesque experience than evoking empathy with refugees, disasters, or war experiences, which typically elicit a stronger response. The short duration of many VR interventions also raises questions about the longevity of their educational impact, particularly in areas such as empathy and writing, as they typically require consistent reinforcement and practice over time. Ultimately, the author suggests that to fully realize the academic potential of VR, future development should focus on designing emotionally rich content, integrating long-term curricula, developing personalized and adaptive learning systems, and ensuring inclusive access for diverse learners.

The two studies demonstrate how VR can align with various educational goals, either enhancing general engagement or promoting deep learning, indicating that the emotional reinforcements of VR can have a positive influence on learning attitudes. However, a key limitation lies in the unclear long-term learning outcomes for both. In Hagge's study, many students without direct access to VR still reported positive perceptions, raising questions about whether perceived value translates into measurable, lasting learning gains (Hagge, 2021). Similarly, while Guan's case improved narrative quality and emotional engagement, the longevity and consistency of these correlations are uncertain among students with diverse backgrounds (Guan et al., 2024). These findings highlight a broader limitation in current VR education research: the lack of empirical evidence confirming sustained skill acquisition across general students. Future studies may address this by incorporating standardized pre- and post-assessments, longitudinal follow-ups, and control comparisons to validate whether VR's perceived impact leads to durable and transferable educational outcomes.

2.2 VR Integration in Healthcare

Beyond education, VR also gained momentum in healthcare, with applications ranging from pain management and rehabilitation to surgical training and mental health support. However, widespread implementation remains inconsistent, constrained by questions of usability, equity, and long-term efficacy. The following reviews examine how current research identifies gaps that remain in realizing the future potential of VR in clinical practice.

Centering on VR integration within healthcare training, Junga et al. evaluate the effectiveness of integrating VR-based brain death diagnostic training modules into medical curricula at the University of Münster (Junga et al., 2025). It monitors a random pilot study comparing traditional manikin-based brain death examinations with a realistic VR ICU scenario aligned with German guidelines, including systematic tutorials and context-setting video podcasts. The study, involving over 800 participants, suggests a positive perception of VR integration, as indicated by an increase in perceived competence in diagnosis. VR stands out, particularly in the trials and adaptation of expensive, non-ethical, and rare operations for training, making the previously conditional and rare experiences more accessible. Furthermore, in comparison to either a book or a real-life scenario, VR establishes a sense of middle ground for students to gain individualized "hands-on" experience without bearing the psychological burden of a real patient. However, while VR practices significantly outperform the traditional education system within the given simulation, we also need to recognize the honeymoon effect of new technology. 14% of participants had no preference for VR or traditional methods, and no significant difference was found between the manikin and no preference groups ($\chi^2(1, N = 86) = 1.2$, $p = .273$), suggesting that not all students saw clear benefits in VR.

Centering on VR integration within clinical settings, El-Gabalawy et al. investigated the feasibility of using VR-based graded motor imagery (GMI) to treat phantom limb pain (PLP) in individuals with lower limb amputations (LLAs) (El-Gabalawy et al., 2025). The author piloted a patient-centered feasibility protocol, including prototype development, feedback collection, pilot testing, and acceptability testing. The outcomes indicate that patients responded positively to the VR-GMI program, and early versions have already improved through feedback. This paper proposes a similar response as previously mentioned in applications in education, particularly the removal of dependence on in-person, specialist physiotherapy, making it scalable, comparatively affordable, and accessible for patients during recovery. While promising in early trials, the authors note that VR interventions often lack evidence of effectiveness across diverse healthcare contexts, geographic regions, and demographics, which limits their broader clinical adoption.

The studies above demonstrate the expanding potential of VR in the field of healthcare, particularly in clinical training and direct treatment. While VR made rare or limited resources accessible, the very implementation of VR brings a persistent barrier, not just in terms of cost, but also in the cognitive and technical burden required to use it effectively for the broader public. Students and patients, particularly those unfamiliar with technology, often encounter prototype-level experiences designed not for them but to them, which can exclude them from meaningful participation despite the therapeutic potential.

2.3 VR Application in Workplace

Likewise, VR is gradually becoming integrated into the workplace, providing safe, scalable, and realistic environments for skill development and collaborative work across various industries. Despite its advantages, adoption varies widely, often limited by organizational readiness, cost concerns, and the need for evidence-based outcomes. The following section reviews current research on VR in workplace contexts, examining its significance, implementation challenges, and potential for future integration.

To explore the presence of VR in the workplace, Arkoulia et al. investigate how collaborative AI and immersive VR simulation can optimize workplace layouts in manufacturing (Arkouli et al., 2024). The researchers utilized VR as a cost-effective method to test and evaluate the design before its concrete implementation, conducting tests in inspired by both on-site restoration of composite materials and post-processing of additive manufacturing parts. The experiment was well received among the engineers as it enabled end-user testing and robust design processes, promoting the sentiment of participatory human-centered design. It demonstrates a democratization in design, giving access to people, particularly operators, the voice to shape their workspace, particularly in qualitative factors such as real-world applicability, ergonomics, and worker comfort. However, the results also reveal that the usefulness of VR depends significantly on the user's expertise in virtual space, particularly understanding and cooperating with the limited integration of sensory and spatial output. Which, with varying levels of familiarity among stakeholders from other fields, may affect the accuracy and consistency of their evaluations.

Katrin et al. examine how VR environments foster "spaces of learning" for the workplace, specifically for training in electrical installation (Kraus et al., 2025). Conducted in Switzerland, the authors employ a mixed-methods approach, combining qualitative interviews with 16 apprentices and 11 trainers, along with quantitative survey data (N = 16), and analyze these data through a socio-spatial lens. The data indicate that apprentices reflected positively on the ease of navigation (M = 3.00) and enjoyment (M = 3.13) but not immersion (M = 2.50). The author hence suggests that apprentices find VR to be more independent, with no consequences, and to eliminate stress; however, they also call for attention to realistic haptic feedback, given complaints about the significant disparities between operating in VR and reality. Meanwhile, trainers appreciated the reduced workload but highlighted a trade-off between autonomous learning and trainer involvement. VR frees them from constant supervision; however, it distances them from the apprentice's learning process.

The applications of VR, demonstrated in both cases, leverage its immersive qualities but serve distinct purposes within the workplace lifecycle. However, lack of realism remains a limitation consistent across these studies, as VR often lacks the complexity of real-world settings, particularly in terms of sensory feedback and physical constraints. Such disconnection can lead to input gathered in VR being detached from real-world use conditions, particularly for testers without VR experience, resulting in design decisions that fall short in practice. Overcoming this limitation may involve integrating mixed reality elements, capturing sensor-based environmental data, or conducting VR evaluations in parallel with real-world simulations to enrich context and validate findings.

3 ANALYSIS

VR as a medium has numerous practical applications in various fields, most of which revolve around virtual embodiment and immersion, rooted in the concept of presence; its limitations also stem from the edge of this notion (Wiepke & Heinemann, 2024). The presence is evident in various ways, as demonstrated by the papers, including emotion, collaboration, accessibility, independence, and realism, with accessibility, in the form of not just cost but actively and properly engaging with the content, being a cross-cutting theme. The usability burden is amplified by patients' varying levels of physical or cognitive ability, exemplified by the front-of-class approach, use of controls, and many more (Wiepke & Heinemann, 2024), making intuitive design a necessity rather than a bonus. The future of VR in

practical fields lies in the ability for institutions to establish a larger ecosystem of support, providing the necessary resources and fostering an environment in which VR usage, even with the burden of adaptation, is convenient. Deriving from this, research should systematically measure the time it takes students from different backgrounds to become proficient in using VR, such as the time it takes to complete tasks confidently, the number of sessions required before independent use, and drop-off rates due to frustration or confusion. Additionally, research should examine how the initial learning burden affects long-term retention, ensuring that early usability barriers do not limit the immersive promise of VR.

Another shared trait shown throughout the papers is independence. VR, in the cases of learning simulations, physical testing, and self-therapy, empowers individuals to take ownership of their learning or recovery by reducing their dependence on institutions, tangible assets, and professionals. However, this autonomy may conceal a deeper dependency on the technology, prompting individuals and researchers to seek a balanced integration. Moving forward, VR will require a gradual, system-level integration into existing workflows, accompanied by simplified user experiences and mainstream-compatible solutions, thereby inviting a larger population into the ecosystem to promote independence and autonomy. The field must proceed with VR not as a standalone solution, but rather as one tool in a broader, human-centered system of design and understanding, promoting researchers to explore when and how VR fosters genuine autonomy versus when it simply shifts dependencies from human providers to technological gatekeepers.

4 CONCLUSIONS

The past few years have seen the rapid development of VR, accompanied by efforts in applications, accessibility, and feasibility, which has led many researchers to conduct experimental case studies to explore the effectiveness and limitations of this technology. The integration of education, healthcare, and the workplace within VR necessitates an examination of its limitations and future insights based on the studies above, with a focus on developing more user-friendly, accessible systems that are both flexible and adaptable. The future of VR applications will not be solely driven by technological advancements, but also by providing thoughtful integration and facilitation of community resources, equitable access, and systematic guidelines. This review highlights the complex and nuanced challenges that VR faces in the current integration in real world applications, summarizing these limitations and outlining future research directions, offering suggestions on the future trajectory of VR, highlight the importance of driving past technological feasibility toward sustainable models of adoption, where VR is not just an innovation but an ingrained part of everyday education, healthcare, and workplace practice.

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