VR/AR IN EDUCATION: IS IT WORTH THE HYPE?

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ABSTRACT

Virtual Reality (VR) and Augmented Reality (AR) offer innovative approaches to education, creating interactive and immersive learning experiences. These technologies enhance student motivation, support personalized learning, and simplify the understanding of complex concepts through hands-on simulations. For instance, students can explore the human anatomy with 3D models or virtually navigate the solar system. However, implementing AR/VR faces challenges, such as high costs, limited infrastructure, and the need for educator training. By adopting a hybrid approach that combines traditional methods with AR/VR, these obstacles can be mitigated. This paper evaluates the potential, benefits, and challenges of AR/VR implementation in education, providing valuable insights for educators and policymakers to effectively integrate these technologies into curricula.

Keywords *: VR/AR, Education, Enhance Learning, Motivation, Personalized.*

INTRODUCTION

Education in today's digital age faces the challenge of adapting to the rapid development of technology. Traditional teaching methods are often unable to meet the needs of diverse students who have different learning styles. Augmented Reality (AR) and Virtual Reality (VR) are emerging as innovative solutions that can enhance the learning experience. These technologies allow students to actively engage in the learning process, creating an immersive experience that supports the understanding of complex concepts. According to recent research, the use of AR and VR in education can improve student motivation and retention, as well as provide opportunities for more effective experiential learning.

Traditional study methods rely on passive learning techniques, such as lectures, textbooks, and note-taking, which often limit students' ability to visualize abstract concepts and engage deeply with the material. In contrast, Virtual Reality (VR) offers an immersive and interactive environment that allows learners to experience and experiment with concepts firsthand. For

example, instead of reading about historical events or anatomical structures, students can "step into" a historical setting or explore a 3D model of the human body. While traditional methods remain effective for foundational learning and accessibility, VR can significantly enhance comprehension, engagement, and retention by catering to diverse learning styles and making complex ideas tangible and experiential.

However, despite the huge potential of AR and VR, there are still many challenges to be faced in their implementation, such as cost, teacher training, and required infrastructure. Therefore, it is important to comprehensively evaluate the impact of these technologies in an educational context, to understand the benefits and barriers that may arise.

The purpose of this paper is to explore and evaluate the potential of AR and VR in education, focusing on how these technologies can improve student engagement, learning outcomes and skill acquisition. This paper also aims to identify the challenges faced in the implementation of AR and VR in educational environments. By understanding these various aspects, this paper is expected to provide valuable insights for educators, decision makers, and technology developers, so that they can design more effective strategies in integrating AR and VR into the curriculum.

METHOD

The method used in this article is the literature review method, where a comprehensive collection of relevant literature on the topic of VR/AR in education, published within at least the past six years prior to the article's publication date, is carefully gathered, analyzed, and synthesized. This approach ensures that the study is grounded in the most recent and significant developments in the use of virtual reality (VR) and augmented reality (AR) technologies in educational settings, providing a robust foundation for understanding their applications, benefits, challenges, and future potential.

FINDING & DISCUSSIONS

ENHANCING LEARNING EXPERIENCE

VR provides a highly immersive and engaging learning environment, allowing students to actively participate in their educational journey. Unlike traditional methods that rely on passive learning through lectures and texts, VR enables students to explore and interact with virtual environments, making complex and abstract concepts more accessible. For instance, VR facilitates virtual field trips, 3D modeling of the human body, and interactive science experiments, which enhance understanding and retention.

The enhanced learning experience through VR bridges the gap between theoretical and practical knowledge. For example, students studying astronomy can virtually explore the solar system, creating a direct connection between classroom concepts and real-world applications. This level of interaction not only solidifies their comprehension but also inspires curiosity and

interest in the subject. However, it is important to consider the cognitive load that some VR experiences may impose, as overly complex designs could overwhelm learners.

To assess the effectiveness of VR-based training compared to traditional classroom instruction, we reviewed a study that compared the exam scores of students who attended a Workflow Management course using the VR tool with those who participated in conventional classroom training. The findings suggest that the VR tool demonstrates greater efficacy than traditional learning methods (see Figure 1).

A t-test was used to compare the performance of students who received VR-based training with those who received traditional classroom instruction. This approach helped identify significant differences in performance between the two groups, supporting the effectiveness of VR-based training. The results showed that the VR group had an average score that was 0.95 higher than the traditional learning group. Furthermore, we are 95% confident that the true mean difference lies between 0.014 and 1.886 (see Table 1). These findings suggest that the VR group performed better on average compared to the traditional learning group.

Despite its benefits, AlGerafi et al. (2023) emphasize that integrating VR into classrooms faces significant challenges. High costs for equipment and limited accessibility in underfunded institutions pose barriers to widespread adoption. Additionally, while VR excels in visual and experiential learning, it may fall short in addressing the needs of students who prefer traditional, text-based approaches. Combining VR with conventional methods could offer a balanced solution to accommodate diverse learning styles.

BOOST MOTIVATION AND SKILL ACQUISITION

Research indicates that VR significantly boosts student motivation by offering a dynamic and interactive platform for learning. Unlike static materials, VR immerses students in lifelike scenarios, encouraging active participation. In skill-based disciplines like engineering, VR simulations provide a safe environment for students to practice repeatedly, honing their skills without the fear of real-world consequences (AlGerafi et al., 2023).

The hands-on nature of VR aligns with experiential learning theories, where students learn better by doing. For instance, medical students can practice surgeries in a virtual operating room, building confidence and expertise. This kind of practical exposure in a risk-free setting is difficult to replicate with traditional methods. Moreover, VR's gamified elements, such as rewards for completing tasks, further motivate students to engage deeply with the material.

Ensuring the quality of these virtual simulations is critical. Poorly designed VR content may fail to replicate real-world scenarios accurately, reducing its effectiveness. Additionally, over-reliance on VR for skill acquisition could limit students' exposure to real-world unpredictability, which is equally important in technical and medical fields. A hybrid approach, combining VR and real-world practice, could address these limitations.

SUPPORTS PERSONALIZED LEARNING

VR fosters personalized learning by adapting to individual students' paces, styles, and needs. It provides immediate feedback and allows learners to revisit challenging topics as often as necessary, creating a self-directed learning environment. This is particularly beneficial for students with diverse learning styles, as VR can tailor content to meet their specific requirements.

Personalized VR environments empower students by giving them control over their learning. For example, a language-learning VR program can adjust vocabulary difficulty based on a student's progress, ensuring an optimal challenge level. Similarly, in subjects like mathematics, VR can guide students through complex problem-solving exercises, offering step-by-step assistance when needed. These features reduce frustration and build confidence, which are crucial for long-term academic success.

The success of personalized VR learning depends on its integration into curricula. Educators must receive adequate training to utilize VR effectively and ensure that its use aligns with educational goals. Additionally, there is a risk that excessive personalization may isolate learners, reducing opportunities for collaborative learning. Balancing individual learning paths with group activities can help maintain a well-rounded educational experience.

THE IMPLEMENTATION OF VR IN EDUCATIONAL FIELDS

From the findings above, we now shift our focus to the actual implementation of VR in educational fields, exploring its impact and effectiveness. Research conducted by Durrani and Pita (2018) highlights that the medical education field leads in adopting AR/VR technologies for teaching and learning. Their study demonstrates that the outcomes of using these technologies are consistently positive, with significant improvements in understanding and applying complex medical concepts. Interestingly, the study also reveals that 11 out of 12 educators in this field took the initiative to design and develop their own AR/VR applications, showcasing not only the adaptability of this technology but also its versatility in meeting specialized educational needs.

Another prominent area of VR/AR integration is engineering education, where, unsurprisingly, all reviewed studies reported favorable outcomes. This highlights the potential of VR/AR to enhance hands-on learning, allowing students to engage with simulations and scenarios that would otherwise be too costly or impractical in a traditional classroom setting.

These examples underline the tangible impact of VR/AR in specific educational fields, proving that its integration is not merely a novelty but a practical, effective tool for enhancing learning. Further reinforcing this, Durrani and Pita (2018) found that out of the 38 studies they reviewed, a remarkable 92% confirmed that VR/AR technologies significantly enhance concept delivery. By replacing passive learning methods with interactive and exploratory approaches,

VR/AR empowers students to engage deeply with study cases, fostering a more immersive and impactful educational experience.

However, while the integration of VR/AR has shown promising results in combinational educational fields like medicine and engineering, its application in more general contexts, such as among undergraduate students, presents unique challenges. Research by McFaul and FitzGerald (2019), which employed a realist approach to examine student responses, provides critical insights into these challenges. Their study specifically analyzed how VR could be utilized to improve students' presentation skills, comparing the initial expectations with the actual outcomes.

The findings revealed significant barriers to successful VR/AR implementation in this demographic. Technical issues, such as hardware or software malfunctions, were cited as one of the primary obstacles. Furthermore, the confidence level of students while engaging with the technology played a pivotal role; some students were hesitant to fully immerse themselves, lacking the motivation or incentives to invest time and effort in mastering the tools. As a result, only a small percentage of students showed genuine engagement and recognized the potential of VR/AR for enhancing their learning experiences.

Adding to these challenges, AlGerafi et al. (2023) highlight that existing research on this technology has primarily focused on technical aspects rather than establishing a strong theoretical foundation for its application in education. While it is true that this area has shown promise as a research subject, it remains underdeveloped in the educational field. Another challenge highlighted is the high cost of implementing this technology.

From these perspectives, it becomes evident that while VR/AR demonstrates undeniable potential in conveying complex concepts and enhancing study cases, its practical adoption still faces hurdles. Bridging the gap between innovation and practical application requires addressing technical shortcomings, reducing costs, and fostering student engagement through well-founded learning strategies. Without these steps, the widespread use of VR/AR in education may remain limited to niche or well-funded settings.

CONCLUSION

Virtual Reality (VR) presents a transformative approach to education, offering an immersive and interactive learning experience that stands in contrast to traditional study methods. While traditional education typically relies on lectures and textbooks, VR allows students to actively engage with complex concepts by exploring virtual environments, conducting experiments, or studying subjects like anatomy in 3D. This hands-on approach not only helps students better grasp challenging material but also stimulates motivation and enthusiasm for learning, creating a more engaging and dynamic educational experience.

Moreover, VR supports personalized learning by adapting to individual students' needs, allowing them to progress at their own pace and receive immediate feedback. This customization enhances the understanding of content and fosters skill acquisition in a safe, controlled environment. While traditional methods offer consistency and accessibility, VR provides a unique opportunity for students to learn through active participation, which may lead to deeper retention and improved outcomes. As the technology continues to advance, VR has the potential to significantly revolutionize the educational landscape, offering a more effective and engaging way for students to learn.

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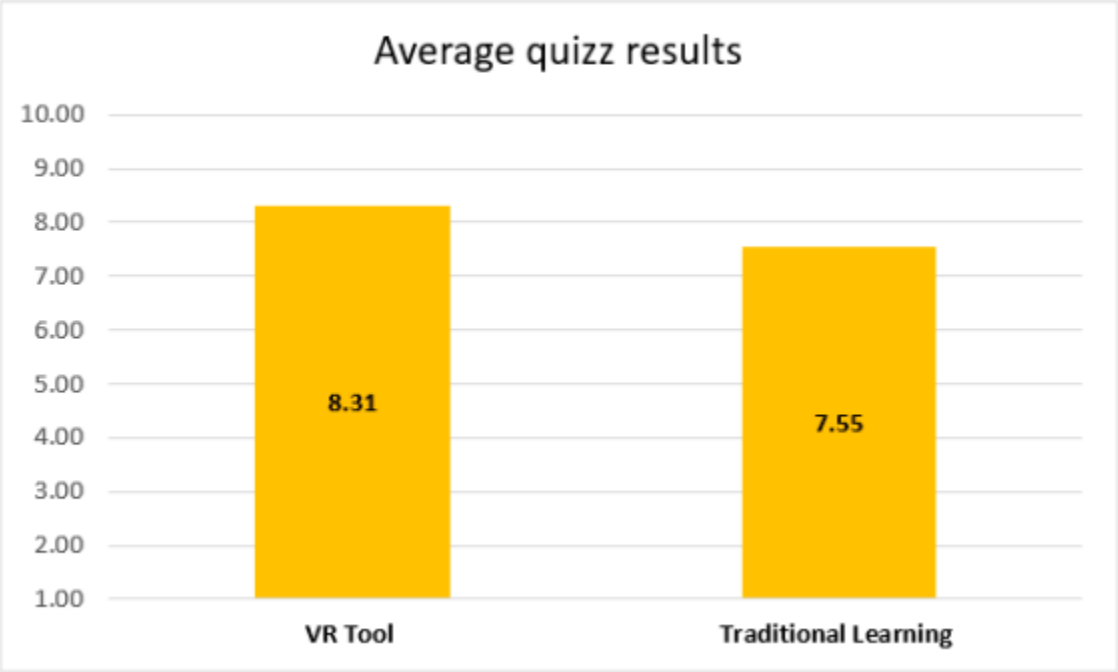
APPENDIX



Group	VR Tool	Traditional Learning
Mean	8.51	7.55
Standard deviation	0.816	1.317
Standard error of the mean	0.258	0.294
N	10	20

1. **Unlocking the Potential: A Comprehensive Evaluation of Augmented Reality and Virtual Reality in Education**

Title	Unlocking the Potential: A Comprehensive Evaluation of Augmented Reality and Virtual Reality in Education
Author	- Mohhamed A. M. AlGerafi, College of Education and Human Development, Zhejiang Normal University, Zhejiang, China. - Yueliang Zhou, Key Laboratory of Intelligent Education Technology and Application of Zhejiang Province, Zhejiang Normal University, Zhejiang, China. - Mohammed Oubibi, Smart Learning Institute,

	Beijing Normal University, Beijing, China. - Tommy Tanu Wijaya, Schools of Mathematical Sciences, Beijing Normal University, Beijing, China.
Year	September 2023
Background on why choosing this research	We selected the article *"Unlocking the Potential: A Comprehensive Evaluation of Augmented Reality and Virtual Reality in Education"* by AlGerafi et al. (2023) because it provides an extensive review of AR and VR applications in education. The study systematically evaluates their impact on motivation, engagement, learning outcomes, and pedagogical practices. Furthermore, it addresses the challenges of integrating these technologies, making it highly relevant for understanding both their potential and limitations in diverse educational settings.
Result	➔ Improved Learning Outcomes. AR and VR help students remember and understand difficult ideas better by letting them experience learning in a more interactive and lifelike way. ➔ Enhanced Engagement, the interactive nature of VR significantly boosts student motivation to be more active during learning activities. ➔ Skill Development, AR and VR provides hands-on-learning experiences, which makes students gain practical skills in a safe controlled environment. ➔ Some challenges on using VR applications in education is the high cost of implementation and a great human resources to effectively integrate the tools

2. **Integration of Virtual Reality and Augmented Reality: Are They Worth the Effort in Education?**

Title	Integration of Virtual Reality and Augmented Reality: Are They Worth the Effort in Education?
Author	- Usman Durrani, School of Information Technology, Ajman University, Ajman, UAE.

	- Zijad Pita, School of Computer Science and Information Technology, Kent Institute, Melbourne, Australia.
Year	December 2018
Background on why choosing this research	We chose the article *"Evaluating the Impact of Virtual Reality in STEM Education,"* presented at the 2018 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE), because it focuses on the specific role of Virtual Reality (VR) in STEM education. This article provides empirical data demonstrating how VR technologies enhance student performance and engagement in technical fields. Despite being published in 2018, we believe the data remains relevant as it offers valuable insights into VR implementation in education.
Result	➔ VR allows students to visualize and interact with complex scientific and engineering concepts that are challenging and more costly to do through traditional methods. ➔ Out of a total of 38 empirical studies analyzed, 92% reported positive outcomes regarding the impact of VR on learning. ➔ The use of VR and AR in education has moved beyond just descriptive analysis and is now also shifting towards a more case-based approach. ➔ While the implementation of VR and AR is still dominantly found in mixed educational fields, the trend is now growing on professional educational domains.

3. **Virtual Reality in Education: A Review of Learning Theories, Approaches and Methodologies for the Last Decade**

Title	Virtual Reality in Education: A Review of Learning Theories, Approaches and Methodologies for the Last Decade
Author	- Andreas Marougkas, Department of Informatics and Computer Engineering, University of West Attica, Egaleo, Greece.

	- Christos Troussas, Department of Informatics and Computer Engineering, University of West Attica, Egaleo, Greece. - Akrivi Krouska, Department of Informatics and Computer Engineering, University of West Attica, Egaleo, Greece. - Cleo Sgouropoulou, Department of Informatics and Computer Engineering, University of West Attics, Egaleo, Greece.
Year	June 2023
Background on why choosing this research	The research titled *"Virtual Reality in Education: A Review of Learning Theories, Approaches and Methodologies for the Last Decade"* was chosen due to the increasing interest in virtual reality (VR) as an educational tool over the last decade. With advancements in technology, VR has become more accessible and is being explored as a powerful means to enhance teaching and learning. This study, authored by experts from the University of West Attica, reviews various learning theories, approaches, and methodologies that have been applied to VR in educational contexts. Understanding the evolution of VR in education is crucial for identifying its benefits, challenges, and future potential in transforming traditional learning environments.
Result	➔ The study identified five educational approaches, one methodology, five theories, and one theoretical framework used in VR in education. These include constructivism, experiential learning, gamification, John Dewey's theory of learning by doing, and flow theory. However, only 30% of the studies in the analysis applied an educational theory or approach, highlighting a gap in the theoretical foundations of many VR-based learning interventions. ➔ The study emphasized that experiential learning theory is particularly suited for VR in education. VR offers learners immersive, interactive environments that allow them to reflect on experiences, conceptualize knowledge, and

	experiment with problem-solving, which aligns with the core principles of experiential learning and enhances learning outcomes. ➔ VR has the potential to revolutionize education by providing engaging and interactive learning experiences. Despite this potential, the study noted limitations due to the small number of reviewed papers and the early stage of research in this field. Future research will explore the impact of VR on learning outcomes, including additional methodologies, learner demographics, and educational contexts.

4. A Realist Evaluation of Student Use of A Virtual Reality Smartphone Application in Undergraduate Legal Education

Title	A Realist Evaluation of Student Use of A Virtual Reality Smartphone Application in Undergraduate Legal Education
Author	- Hugh Mcfaul, founding member of the Open University Law School's Open Justice Center, UK. - Elizabeth FitzGerald, lecturer at the Institute of Educational Technology at Open University, UK.
Year	July 2019
Background on why choosing this research	We chose the article *"A Realist Evaluation of Student Use of a Virtual Reality Smartphone Application in Undergraduate Legal Education"* because it offers comprehensive insights into how VR is implemented in real-world educational settings, specifically in general academic environments.
Result	➔ By using a realist approach, it helps to identify the key factors on why VR/AR are great to be implemented in education or even on why VR/AR didn't met the satisfaction of the students. ➔ By using this expectation CMO configuration. We knew that this is the expected outcome after using VR/AR.

Context	Mechanism	Outcome
C1 Final-year law students	M1 Students will take time to familiarise themselves with the VR APP	O1 Increased confidence in giving presentations
C2 Have received some presentation skills training	M2 Students will practice their presentations within an immersive virtual reality environment	O2 Increased understanding of importance and relevance of communication skills
C3 Will have opportunity to apply presentation skills in real-world settings	M3 Students will fully utilise the feedback functionality provided in the VR app	O3 Identify and set goals for improving real-world presentation skills
C4 Varying levels of confidence and experience in giving presentations	M4 Students will use the VR app to practice and refine their real-world presentation	O4 Foster the understanding of the relevance and importance of transferrable professional skills

➔ After using the VR/AR we get this table, which shows that the VR/AR applications are not what to be expected, only a small percentage of students knew the actual potential, while the rest of them tend to not see it like that.

Table 2: Summary of CMO themes from interview data

Contexts	Mechanisms	Outcomes
C1 Time limitations	M1 Disappointment with the quality and functionality of the VR app and Headset	O1 Did not use the VR app to practice presentation skills after the first attempt
C2 Relationship to the wider module	M2 Perception that VR technology was beyond their technical capabilities	O2 Used other means to practice presentation skills
C3 Lack of confidence or anxiety in engaging with new technology	M3 Valued the generation of presence within VR and the potential for group collaboration but the current version did not warrant time required to use it.	O3 Used the full functionality of the VR app to practice presentation skills.
C4 Readily available expert assistance	M4 Perceived lack of incentives to put the time into learning how to use the VR app	
C5 Quality and functionality of VR app and VR Headset	M5 Valued the generation of "presence" within VR and perception that it was useful and worth time to understand how to use it	

➔ All the findings show that average students did not see the software used by the VR to be a sufficient value for them to invest their time in. This finding just gives us a greater look on what makes VR/AR not massively implemented in the general academic fields, because not only does it cost a lot but also, you need skilled human resources to maintain or create software that is suitable for students to use.

➔ This article also shows that the problem on why VR is not massively implemented is that the technical side, such as the comfort of using the VR headset, student's confidence on using new kinds of technology, students familiarity, and the software itself is lacking, not the technology.

5. Impact of VR Application in an Academic Context

Title	Impact of VR Application in an Academic Context

Author	- Stefania-Larisa Predescu (Burciu), Doctoral School on Automatic Control and Computer Science, Politehnica University of Bucharest, Bucharest, Romania. - Simona Iuliana Caramihai, Doctoral School on Automatic Control and Computer Science, Politehnica University of Bucharest, Bucharest, Romania. - Mihenea-Alexandru Moisescu, Doctoral School on Automatic Control and Computer Science, Politehnica University of Bucharest, Bucharest, Romania.
Year	April 2023
Background on why choosing this research	The research titled *"Impact of VR Application in an Academic Context"* was chosen due to the increasing integration of Virtual Reality (VR) in education. As technology continues to advance, VR is being explored as a tool for enhancing traditional teaching methods. This study, authored by experts from the Doctoral School on Automatic Control and Computer Science at Politehnica University of Bucharest, investigates the potential impact of VR applications in academic settings, focusing on how it can improve learning outcomes, engagement, and the overall educational experience. The growing interest in VR's educational benefits, combined with the need to assess its practical effectiveness, makes this research highly relevant for understanding the future of education in a digital age.
Result	➔ The use of VR in education significantly increased student engagement, as demonstrated by higher quiz success rates (90%) and improved performance in the Workflow Management course. The VR tool's multimedia elements and voice recognition features fostered a sense of collaboration and community, enhancing both knowledge retention and efficient learning compared to traditional classroom settings. ➔ The VR system improved accessibility to educational resources through voice recognition, allowing students to search for information and

	multitask seamlessly while navigating the VR environment. This feature enhanced the efficiency of knowledge acquisition, reducing cognitive load and the time spent on manual searching, promoting a more effective learning experience. ➔ The VR platform facilitated collaboration through its video conference system and immersive classroom environment. However, limitations such as dizziness, headaches, and motion sickness after prolonged use were noted. Additionally, the need for highly detailed multimedia content aligned with course objectives was emphasized to maximize the learning experience. Despite these drawbacks, the overall integration of VR into education showed substantial benefits, though it should complement traditional methods for optimal results.