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The Impact and Challenges of Integrating Virtual Reality (VR) Technology in Modern Education: Systematic Literature-view

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Abstract

In recent years, virtual reality (VR) technology has gained significant attention in education, highlighted by various reports such as the NMC/CoSN Horizon Report K-12 (Becker et al., 2017), the Monterey Education Technology Innovation Observatory's Education Trends Report (2017), and the 2020 EDUCAUSE Horizon Report (Brown et al., 2020). These reports emphasize VR's potential to transform educational environments by providing immersive learning experiences. VR's ability to create realistic, engaging scenes can stimulate students' curiosity and improve engagement and knowledge retention (Merchant et al., 2014). It also addresses challenges of traditional field trips, such as financial and logistical constraints (Al-Samarraie & Saeed, 2018). Despite its promise, VR faces challenges including high costs and integration difficulties in classroom settings. Continued research and promotion are essential for VR's successful adoption, which holds the potential to revolutionize education and enhance teaching quality.

Keywords

VR; Education; Challenges.

1. Introduction

In recent years, virtual reality (VR) technology has sparked considerable interest and attention in education. From the NMC/CoSN Horizon Report K-12 (Becker et al., 2017)to the Monterey Education Technology Innovation Observatory's Education Trends Report (2017), and the 2020 EDUCAUSE Horizon Report(Brown et al., 2020), all emphasized VR technology as one of the key trends in educational innovation. These reports point out that VR technology provides an immersive learning experience and will profoundly impact the educational environment in the next few years.

The appeal of VR technology mainly lies in its ability to create a highly immersive learning environment, allowing students to feel as if they are in a real-life scene. This immersion can stimulate students' curiosity and interest in learning, increasing their learning engagement. Research shows that after students participate in VR field trips, they show higher engagement and better knowledge retention in the learning process(Merchant et al., 2014). This simulated field trip experience enables students to understand course content better and apply what they have learned to real-world situations.

Additionally, using VR technology can overcome various challenges faced by traditional field trips, such as financial constraints and logistical issues. Through virtual reality technology, students can experience various scenes and environments without being there, thus avoiding all the inconveniences caused by field trips (Al-Samarraie & Saeed, 2018).

However, despite the vast potential of VR technology in education, its application still faces some challenges. One of them is the availability and cost of technology. Although the price of VR equipment is gradually declining, a large amount of money is still required to purchase and

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maintain this equipment, which may be a considerable burden for some schools with limited resources. In addition, teachers may also have certain confusions and challenges on how to integrate VR technology into classroom teaching effectively.

In conclusion, virtual reality (VR) technology is a powerful tool that can give students a more prosperous, immersive, and practical learning experience, even though it is still in its infancy and confronts some problems. Therefore, further research and promotion of the application of VR technology in education will positively impact educational reform and improve teaching quality.

2. Literature Review

Virtual reality (VR) technology is an emerging field that is receiving increasing attention in education in the modern digital age. This paper examines how virtual reality (VR) technology can be used in the classroom and examines how it affects student engagement and learning outcomes. As technology has advanced over the past several years, an increasing amount of research has started to concentrate on the potential benefits of virtual reality technology for education. This article will examine the use of VR technology in education across disciplines and age groups after reviewing the literature that has already been published. Subsequently, an analysis will be conducted on how VR technology affects student learning effectiveness, involvement, and teaching approaches. Lastly, this study will go over the shortcomings of the previous research and suggest new lines of inquiry.

According to Villena-Taranilla et al. (2022), they conducted a meta-analysis to explore the impact of virtual reality (VR) technology on the learning outcomes of K-6 students. By synthesizing the literature from 2010 to 2021, the impact of VR on K-6 students' learning outcomes was explored. This study focuses on applying VR technology among K-6 students and aims to evaluate its impact on learning outcomes. Specific research questions include evaluating the effects of different types of VR technology on student learning, exploring best practices for using VR technology, and identifying potential applications of VR technology in different subject areas. Research has found that VR technology positively impacts the learning outcomes of K-6 students, especially with the application of immersive VR technology.

Furthermore, short-term interventions have been shown to be more effective than long-term interventions. However, the long-term effects are unknown. This study fills a research gap on the impact of VR technology use among students in kindergarten to sixth grade in education. On the orther hand, the research by Alqudah and Khasawneh (2023)focused on exploring the impact of VR field trips on student engagement and learning outcomes. They adopted a quantitative research approach and analyzed a sample of students from educational institutions in the context of Saudi Arabia and Jordan.

The results of the study showed that there was a significant positive correlation between student engagement and academic performance, while socioeconomic status showed a significant correlation with academic performance. This research highlights the importance of active participation in education and the potential of VR technology to increase student engagement. The study found that there is a significant positive correlation between student engagement and academic performance, but the impact of different student groups needs further exploration.

Research by Xin (2022)pointed out that VR-based teaching environments can significantly improve students' emotional and cognitive investment, which is associated with significant advantages in academic performance. By comparing the experimental and control groups, they found that the experimental group performed significantly better than the control group in the immediate test and one week later, demonstrating the effectiveness of learning in a virtual reality environment. This study further verifies the important role of VR technology in

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education and provides a significant reference value for VR-based teaching design. Research has found that VR environments significantly improve students' emotional and cognitive engagement while positively impacting learning outcomes. However, the specific mechanisms of these improvements still require further study.

The research of Akman and Çakır (2023)emphasized the positive impact of educational virtual reality technology, especially the impact of educational virtual reality games on students' academic performance and subject investment. Their research shows that virtual reality environments provide students with opportunities to gain a deeper understanding of abstract scientific concepts and enhance student interaction with media resources. This research further highlights the potential of VR technology to improve student learning and maintain student engagement in the subject. However, the application of educational virtual reality technology in different disciplines and student groups still requires in-depth research.

Petare and Shamim (2023)synthesized the existing literature and explored the impact of virtual learning environments (VLEs) on student engagement and academic performance. These environments create a more engaging learning environment for students by providing a personalized and flexible learning experience. Their findings showed that VLEs had a positive impact on the motivation, engagement and academic performance of different types of learners. It also improves collaborative learning and social interaction among students. In particular, VLEs play an essential role in improving students' digital literacy, technology skills and problem-solving abilities. However, there are still research gaps in the impact of VLEs on different learner types and challenges in the implementation process, which require further in-depth research and discussion.

3. Methodology

Villena-Taranilla et al. (2022)used a systematic literature review and meta-analysis approach to evaluate the impact of virtual reality (VR) technology on the learning outcomes of K-6 students. They first searched academic databases through keywords, including Google Scholar, PubMed, etc., and obtained relevant literature from 2010 to 2021. Subsequently, 4658 documents were initially screened, and 21 experimental studies were included for meta-analysis. In terms of research methods, they strictly followed the requirements of the Preferred Reporting Items (PRISMA) for literature screening, data extraction and analysis to ensure the credibility and scientificity of the research. In addition, they also referred to the Cochrane Handbook's recommendations for systematic reviews of interventions to ensure the rigour and validity of research methods.

Alqudah and Khasawneh (2023)used a quantitative research approach to explore the impact of virtual reality field trips on student engagement and understanding through field trips and questionnaires. They randomly selected 215 adolescents aged 15 to 17 at educational institutions in Saudi Arabia and Jordan and assigned them to either VR or traditional fieldwork groups. Student engagement was assessed through the Student Engagement Scale developed by Fredricks, Blumenfeld, and Paris (2004), while knowledge tests were designed based on national curriculum standards. Statistical analysis methods, including multiple regression analysis, were used to analyze the results, highlighting the importance of student engagement in predicting academic performance and the impact of socioeconomic status on learning outcomes.

The research subjects of Xin (2022) were sophomores and juniors from different majors in the School of Architectural Engineering of an ordinary provincial university in Henan Province. The study adopted an experimental group and control group design, with a total of 82 subjects participating. The experimental group learned through VR-based teaching mode, while the control group used traditional offline face-to-face ppt teaching mode. The research results

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highlight the importance of learning task design in virtual reality environments and the need to consider the connotation and design principles of complex tasks to promote the development of students' comprehensive cognitive skills.

Akman and Çakır (2023)mainly used mixed methods for research, combining the collection and analysis of quantitative and qualitative data. They conducted the study among fourth-grade students at a private school in Turkey, with a total of 64 students participating. Data collection tools included the Fractional Academic Achievement Test (AAT) and the Student Engagement in Mathematics Scale (SEMS), as well as teacher and researcher observation notes. During the application of educational virtual reality games, students used virtual reality headsets and took turns playing the games in a classroom environment, with each part being approximately 10-15 minutes long.

The study by Petare and Shamim (2023)adopted a systematic research approach. They collected relevant research literature between 2010 and 2021 by comprehensively searching academic databases and manually searching bibliographies and formulated inclusion criteria for study selection. Next, they extracted relevant data from the selected studies. They used thematic analysis to synthesize and analyze the data to identify the key influencing factors of VLEs on student engagement and academic performance.

4. Findings

Article 1:

Findings: The impact of VR technology on learning outcomes for K-6 students.

Key Findings: The use of immersive VR technology significantly enhances student learning, especially under short-term interventions

Table 1. Outcomes for K - 6 students

Learning Mode	Average Gain
Traditional	0
Immersive VR	0.64

Article 2:

Findings: The effect of VR field trips on student engagement and learning outcomes.

Key Findings: Student engagement correlates positively with academic performance, while gender shows no significant relationship with learning outcomes. However, socioeconomic status correlates significantly with academic achievement.

Table 2. Effect of VR for learning outcomes

Variable	Correlation
Student Engagement	Positive
Gender	No significant relationship
Socioeconomic Status	Significant correlation

Article 3:

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Findings: The impact of VR-based teaching models on student emotional and cognitive engagement, as well as learning outcomes and knowledge retention.

Key Findings: Learning in virtual reality significantly improves student learning effectiveness and knowledge retention, with cognitive engagement mediating the effect.

Table 3. Teaching model

Variable	Average Score/Engagement
Experimental Group Emotional Engagement	3.366
Control Group Emotional Engagement	2.5
Experimental Group Cognitive Engagement	3.854
Control Group Cognitive Engagement	2.8

Article 4:

Findings: The influence of educational VR games on student learning outcomes and mathematical engagement.

Key Findings: Educational VR games enhance learning outcomes and maintain student engagement in mathematics.

Table 4. Enhancing learning outcomes

Learning Mode	Learning Outcome Gain
Traditional Teaching	0
VR Math Game	Learning Outcome Gain

Article 5:

Findings: The positive impact of VLEs on student learning motivation, interest, and engagement, but challenges remain in implementation.

Key Findings: VLEs have a positive impact on learning motivation, engagement, and academic performance across different types of learners, but challenges exist in implementation.

Table 5. Learning motivation

Variable	Impact Level
Learning Motivation	Positive
Engagement	Positive
Academic Performance	Positive

5. Conclusion

Based on the research results of the above five documents, it can be seen that the application of virtual reality (VR) technology in the field of education has significant potential. The meta-

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analysis by Villena-Taranilla et al. (2022)revealed the positive impact of VR on the learning outcomes of K-6 students, especially the more significant effect in the immersive VR environment. This finding provides strong support for future educational practice, indicating that VR technology can be used as an effective teaching tool to promote student learning and development.

Meanwhile, research by Alqudah and Khasawneh (2023)highlights the positive relationship between student engagement and academic performance, as well as the impact of socioeconomic status on academic performance. This finding suggests that we need to pay attention to student engagement, especially when using VR technology for teaching, to improve student learning outcomes. In addition, Xin (2022) research further verified the positive impact of VR-based teaching models on students' learning effects and emphasized the importance of teaching task design. This shows that when using VR technology for teaching, it is necessary to focus on designing challenging and inspiring learning tasks to stimulate students' learning interests and improve their learning effects.

In addition, the study by Akman and Çakır (2023)studied the impact of educational virtual reality games through mixed methods, providing us with a deeper understanding of how and what effects VR technology has on education. Through comprehensive analysis of quantitative and qualitative data, they verified the effect of educational virtual reality games on improving academic performance and revealed its essential role in promoting student participation and emotional investment. Finally, Petare and Shamim (2023)study examined the impact of virtual learning environments (VLEs) on student engagement and academic performance systematically, providing us with a comprehensive research perspective and theoretical framework. Their findings further highlight the positive role of VLEs in promoting students' learning motivation, interest, and engagement while also pointing out challenges and barriers that may be faced in implementing VLEs.

By comprehensively analyzing the research results of Villena-Taranilla et al. (2022), we found that VR technology has a significant positive impact on the learning outcomes of K-6 students. This is consistent with the findings of Alqudah and Alqudah and Khasawneh (2023), who highlighted the positive relationship between student engagement and academic performance. It is particularly noteworthy that Xin (2022) research further emphasizes the importance of task design in VR teaching environments, indicating that designing challenging and attractive learning tasks can enhance students' learning outcomes.

This article offers valuable insights into how emerging technologies, notably virtual reality (VR), influence student learning outcomes and engagement across various educational contexts. By reviewing five pivotal studies, notable findings regarding the effects of VR technology on student engagement, academic performance, and the holistic learning experience have been uncovered.

Villena-Taranilla et al. (2022)conducted a systematic literature review and meta-analysis that highlighted the positive impact of VR on learning outcomes for K-6 students. Their rigorous research methods ensure the reliability and validity of the research results. This research provides important clues to our understanding of the potential of VR technology to enhance student learning experiences in early education and primary education. However, further research on long-term effects is needed to assess the potential of VR technology in education fully.

Alqudah and Khasawneh (2023)focused on the impact of virtual reality field trips on student engagement and understanding in Saudi Arabia and Jordan. Through a quantitative study of 215 adolescents, they found a significant positive correlation between student engagement and academic performance, while also emphasizing the impact of socioeconomic status on academic performance. This research sheds light on the differences between different

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educational groups and how technology can be better used to promote educational equity. However, they also point to the impact of socioeconomic status on learning outcomes, which requires further research to promote equity in education.

Xin (2022) explored the impact of VR-based teaching models on the learning outcomes of undergraduate students in a Chinese university. Through comparisons between experimental and control groups, he demonstrated the effectiveness of VR technology in improving cognitive abilities and academic performance. This research highlights the importance of instructional design in maximizing the benefits of VR technology. However, this improvement's specific mechanism and long-term effects still require further research and verification.

Akman and Çakır (2023)used a mixed methods approach to study the impact of educational virtual reality games on student learning outcomes. They integrated quantitative and qualitative data to explore the mechanism of VR intervention learning experience deeply. This research provides a more comprehensive understanding of how VR games can improve student engagement and academic performance. However, the applicability across different disciplines and student groups still needs further investigation.

Petare and Shamim (2023)systematically analysed the impact of virtual learning environments (VLEs). By synthesizing existing research, they identified key factors that influence the effectiveness of VLEs, such as personalized learning experiences and technical support. This study highlights the importance of technological infrastructure and teaching support in maximizing the potential of VLEs. However, further research remains on the impact of VLEs on different learner types and challenges in implementation.

The above research findings indicate that emerging technologies, especially virtual reality (VR) and virtual learning environments (VLEs), have substantial transformational potential in shaping contemporary educational practices. These studies highlight the critical role of technology in improving student learning outcomes, promoting student engagement, and providing diverse learning experiences.

Future research should be dedicated to exploring the application effects and mechanisms of emerging technologies in different educational environments, focusing on the role of technology in promoting educational equity and meeting diverse learning needs, and exploring technology integration and innovative teaching models to improve student engagement. and learning outcomes.

In addition, strengthening interdisciplinary cooperation and promoting the combination of technology and educational theory and will help promote the sustainable development of the education field. From a practical perspective, investing in technology infrastructure and professional development, and integrating emerging technologies into educational settings, can help foster inclusive learning environments that support student success in the digital age. These efforts will provide important inspiration for innovation and improvement in education, thereby promoting social progress and development.

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