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Research on the Application of Virtual Reality Technology in Immersive Teaching and Classroom Teaching Effect

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Abstract
This study aims to examine the influence of virtual reality (VR) technology on immersive teaching methods and its subsequent impact on educational outcomes. Specifically, it seeks to explore how VR contributes to enhancing teaching effectiveness, student engagement, and overall learning experiences, with particular emphasis on the role of student motion recognition and target tracking technologies. A qualitative approach was utilized, comprising 18 semi-structured interviews with faculty members experienced in VR-based teaching. The data were analysed using a three-step thematic analysis to identify key themes and patterns related to the impact of VR on educational practices. The study found that VR significantly enhances teaching effectiveness by integrating interactive learning elements and improving the visualization of complex concepts. Students demonstrated higher levels of engagement and participation during VR sessions, although challenges related to technical issues and logistical constraints were identified. Furthermore, student motion recognition and target tracking technologies facilitated personalized learning experiences; however, these technologies also introduced challenges, including student discomfort and limitations arising from technological constraints. This research addresses a gap in the literature by providing empirical evidence regarding the impact of VR on teaching and learning outcomes. It offers practical insights into overcoming the challenges associated with VR integration and optimising its use in education, emphasising its potential to transform educational practices and enhance student engagement.

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Introduction

VR technology has rapidly transitioned from entertainment to education, significantly altering the landscape of learning in schools. Since its introduction in the mid-20th century, VR has evolved, driven by advances in computing, graphics, and sensory devices (Van Hooijdonk et al., 2022). It offers students immersive learning experiences that are difficult to achieve through traditional teaching methods. The ability of VR to simulate reals-world scenarios and events allows learners to engage with complex subjects that would be challenging to explore in a conventional classroom setting. This technological evolution is reshaping pedagogical approaches, presenting new opportunities to enhance educational practices (Yamac et al., 2023).

Immersive teaching methods, particularly those utilising VR, have gained traction due to their potential to improve learning outcomes by creating engaging and dynamic learning environments. Through interactive and immersive experiences, students become fully engaged in their educational activities (Kadri et al., 2024). Research suggests that immersive technologies such as VR can enhance student motivation, comprehension, and retention. By immersing students in virtual environments, these technologies foster critical thinking and active learning, shifting the educational experience from passive reception to active participation, thereby improving cognitive abilities and making education more engaging (Stucki et al., 2024). In immersive educational settings, technologies such as student motion recognition and target tracking are increasingly integral. VR systems are capable of interpreting students' bodily gestures, making learning more interactive and adaptable (Wang & Yan, 2019). This feature enhances the realism of VR interactions by synchronising virtual elements with students' physical movements, thereby improving the fidelity of teaching simulations. Target tracking, meanwhile, involves monitoring students' focus and behaviours within the VR environment to assess their level of engagement and comprehension (Mathur et al., 2023). By personalising the virtual learning experience based on students' actions and responses, these technologies contribute to more effective and tailored teaching.

Educational technology has progressed with the integration of VR motion detection and target tracking, enabling instructors to design engaging and adaptive learning experiences that cater to individual student needs (Yamac et al., 2023). Motion detection facilitates dynamic, physical activities that enhance student motivation and engagement (Yin et al., 2023). Meanwhile, target tracking enables instructors to assess student performance and engagement throughout the learning process, allowing for real-time adjustments to teaching strategies and content delivery (Mutua et al., 2023). The adaptability and customisation offered by VR, supported by this interactive

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feedback loop, contribute to improved learning outcomes. As educational approaches continue to evolve, technology plays an increasingly crucial role. Traditional classrooms often struggle to provide hands-on, meaningful learning experiences due to budget constraints and the challenge of simulating real-world scenarios (Wang et al., 2023). However, the interactive and immersive features of VR overcome these limitations by allowing students to engage actively with complex topics in a controlled yet realistic environment. Motion detection and target tracking further enrich student interactions, enhancing their skills and facilitating the integration of theory with practice.

Research suggests that VR has the potential to transform teaching methods by creating immersive learning environments that enhance student engagement and understanding (T et al., 2020; Wang & Cai, 2023). VR enables students to experience complex concepts, such as astronomical events and chemical structures, improving involvement and curiosity. Lei et al. (2022) found that VR's immersive nature can motivate students to learn, while Chan et al. (2023) showed VR's effectiveness in engaging history students more than traditional methods. According to Wagener et al. (2021), VR's interactive features boost student engagement and attention. Additionally, VR motion detection and target tracking enhance teaching adaptation and engagement. Motion detection allows real-time feedback and personalised learning, as noted by Yin et al. (2023), while Chen et al. (2020) recommended VR motion tracking to monitor attention and improve learning outcomes.

This study aims to advance VR education research, addressing the lack of empirical evidence on how VR affects learning outcomes and instructional efficacy across diverse educational settings. While VR has been shown to enhance student engagement and comprehension of complex topics, its impact on academic performance and teaching effectiveness remains uncertain (Kadri et al., 2024). This study fills this gap by examining the effects of VR immersion on both student and teacher performance. The literature also overlooks the technological and logistical challenges of implementing VR in the classroom. Despite previous studies highlighting barriers to VR adoption, few have investigated issues related to technology and resource constraints (Stucki et al., 2024). This research seeks to explore these challenges and provide potential solutions, while also examining how motion detection and target tracking can further enhance student engagement and personalised learning. Further investigation is needed to assess their full impact.

This study aims to address existing research gaps by investigating the impact of VR technology on immersive teaching methods, as well as the associated technical and logistical challenges. The primary objective is to explore how VR enhances teaching effectiveness, student engagement, and the overall learning experience. By examining the integration of VR in educational contexts, the research seeks to identify both the benefits and challenges of VR-based teaching. Additionally, the study will investigate

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the role of student motion recognition and target tracking technologies in immersive learning environments. Ultimately, the research aims to provide insights into how VR can address complex educational challenges and contribute to the development of more effective teaching strategies.

There are several compelling reasons for conducting this inquiry. Research indicates that VR has the potential to enhance academic performance and student engagement. Despite its promise to improve educational outcomes, the impact of VR on student performance has not been extensively explored. This study aims to address this gap by investigating how VR can contribute to educational improvement. While VR training offers significant benefits, it also presents technological and practical challenges. The literature recommends that educators and institutions implementing VR in training carefully consider available resources and technological limitations. Such considerations are essential for the successful integration of VR into educational settings. The study also highlights that student motion tracking and target monitoring can enhance VR-based learning by fostering more personalised and engaging learning experiences. By exploring both the advantages and challenges of these technologies, the research contributes to a deeper understanding of how VR can impact student engagement and individualised learning. Policymakers, educators, and technology developers can benefit from the findings of this study, which suggest that VR has the potential to transform teaching methods and shape the future of education.

Literature Review

VR is transforming education by providing immersive, engaging learning environments that differ significantly from traditional methods. VR can enhance student motivation and participation by making learning more interactive and visually appealing. It accommodates various learning styles, offering a customised and adaptive approach. However, challenges such as accessibility, cost, material quality, and alignment with instructional goals must be addressed for successful VR integration. Despite these obstacles, VR has the potential to make passive learning more dynamic, improving spatial awareness, problem-solving, and the visualization of complex concepts, thereby enhancing classroom performance. VR aligns with the growing trend of digital transformation in education and technology-mediated learning.

Virtual Reality in Education

VR has evolved from an experimental tool to a powerful educational resource, significantly enhancing learning experiences. Initially limited to research labs and specialized applications due to high costs and restricted accessibility (Xu et al., 2023), VR gained popularity in interactive learning and training simulations with advances in computer graphics and processing in the early 21st century (Gargrish et al., 2020). These technological advancements have made VR a viable educational tool, offering

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more realistic and engaging simulations. In business education, VR exemplifies how technology can enhance learning by creating immersive environments that replicate real-world scenarios. For instance, VR financial market simulations allow students to engage in trading and strategy development without financial risk, fostering skills in financial analysis and decision-making (Catala et al., 2023). Virtual site visits and excursions provide students with global business insights, offering perspectives that traditional classrooms cannot (Gargrish et al., 2020). Case studies demonstrate VR's potential in leadership and management education, where simulations place students in real-life situations to develop problem-solving and decision-making skills (Lei et al., 2022). Additionally, VR role-playing in sales training enhances persuasion, communication, and the ability to respond to feedback. In entrepreneurship education, VR fosters innovation and creativity by replicating business environments where students can test ideas, explore market potential, and navigate start-up challenges (Qiu et al., 2023). Through these immersive experiences, VR enables students to apply classroom knowledge in real-world contexts, making it a transformative tool for business education.

Immersive Teaching Methods

Many educational theories emphasize the importance of active engagement and hands-on learning, which are fundamental to immersive teaching. Experiential learning theory highlights the value of first-hand experience in the learning process (Jackson, 2024), and VR serves as a key tool for creating such immersive environments. By simulating real-life events and scenarios, VR engages students through dynamic, visually captivating surroundings, enabling virtual visits to historical sites, scientific labs, and business simulations (Lan et al., 2024). This multisensory experience—incorporating visual, auditory, and kinesthetics stimuli—enhances memory and cognition, making learning more engaging and memorable than traditional methods (Kane et al., 2022). VR's interactive capabilities allow students to manipulate virtual objects, conduct experiments, and observe real-time results, fostering a constructivist approach that encourages critical thinking and problem-solving (Tan et al., 2022). Additionally, VR's collaborative features align with social constructivism, promoting social interaction and teamwork. By providing access to materials otherwise unavailable, VR overcomes time and space barriers, making it especially valuable in subjects like physics and history where real-world experiences are limited (Xu et al., 2023). Virtual field trips, simulations, and interactive activities broaden educational opportunities, and VR environments can be tailored to suit different learning styles, enabling individualized learning and allowing students to explore complex topics at their own pace.

Classroom Teaching Effect

For years, education was dominated by lectures, textbooks, and passive learning, where students mainly listened and recorded information. This traditional approach

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often fails to accommodate diverse learning styles, reducing student engagement and retention (Khamsuk & Whanchit, 2021). Moreover, it lacks interactive learning and real-world applications, creating a divide between academic theory and practical experience. VR and other immersive education methods are transforming this by providing dynamic, engaging learning environments. VR immerses students in real-world simulations and interactive experiences, which enhances engagement and facilitates deeper cognitive processing (Lin & Wang, 2021). Unlike traditional lectures, VR supports constructivist learning by encouraging active participation and collaboration, allowing for real-time feedback and problem-solving (Eswaran & Bahubalendruni, 2023). This personalized, gamified approach motivates students and supports customized learning that aligns with their interests and needs (Fondo & Gómez-Rey, 2021). VR's ability to provide immediate feedback and simulate complex scenarios offers advantages over traditional methods, where feedback is often delayed and limited to graded assessments (Qiu et al., 2023).

Student Motion Recognition and Target Tracking

Target tracking and student motion detection technologies have significantly enhanced the interactivity of education. Initially, early motion detection systems were limited, relying on keyboards and mice for input from both teachers and students (Amos et al., 2022). However, advances in photography, accelerometers, and depth sensors have transformed the way teachers monitor student behaviour, enabling real-time tracking of students' movements (Siegel, 2022). These innovations facilitate a dynamic and engaging learning environment by detecting gestures and movements through depth and motion cameras, allowing students to actively participate in hands-on activities (Thornquist, 2018). Technologies such as target tracking and motion detection have revolutionised student engagement, customisation, and adaptive learning by enabling students to interact physically with digital content. This leads to greater immersion and more dynamic learning experiences. For instance, interactive exercises allow students to engage with virtual objects based on their body movements, facilitated by tools like interactive whiteboards and motion-tracking VR systems (Wang & Yan, 2019).

The increased interactivity fostered by these technologies improves student engagement and academic enthusiasm, creating more responsive and personalised learning environments. Motion detection and target tracking technologies enable instructors to tailor lessons to individual student needs by monitoring behaviour, communication, and performance in real time (Yamac et al., 2023). Adaptive learning systems utilise data from motion tracking to adjust the intensity of tasks, provide personalised feedback, and support students who may be struggling. This personalisation enhances learning by adapting to the specific learning styles and paces of students. Moreover, motion-tracking technologies in educational games and simulations can adjust to students' gestures and performance, continually

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personalising the learning experience and improving over time (Mutua et al., 2023). The flexibility afforded by these technologies allows for customised assignments and feedback that inspire students by addressing their unique learning needs and competency levels. By continuously monitoring and analysing student movements and interactions, educators can identify patterns, assess participation, and make data-driven decisions to enhance both teaching and learning outcomes.

Methodology

Research Design

This study examined the complex attitudes of educators and practitioners towards VR in education through qualitative research. A qualitative approach was chosen for its ability to thoroughly explore intricate and nuanced situations that are difficult to quantify. As noted by Creswell (2017), the subjective experiences of VR users are better understood through qualitative methods than through quantitative analysis. Semi-structured interviews were conducted to investigate VR's impact on teaching and learning. This method revealed the flexibility of VR in educational settings and provided insights into its effects on student engagement, teaching practices, and classroom dynamics.

Participants

The participants were purposefully selected to provide valuable insights into the use of VR in business education. Criteria were established to ensure that participants had relevant experience with VR in education. Business school faculty members with hands-on VR experience were chosen to offer practical perspectives on immersive learning and teaching. The selection process aimed to identify educators who had actively engaged with and produced VR-based educational content, particularly those advocating for interactive and immersive teaching methods.

Faculty directories, professional networks, and industry contacts facilitated participant recruitment, with a focus on ensuring a diverse range of experiences and viewpoints (Table 1). Invitations were sent to potential participants explaining the study's objectives and the interview process. Consent forms informed participants of their rights, including confidentiality. Ultimately, 18 business school educators with VR and immersive teaching experience were selected, providing a broad spectrum of expertise to assess the impact of VR on education (Bryman, 2016).

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Table 1: Profile of Respondents

Respondent ID	Position	Years of Experience	Department	Experience with VR	Mode of Participation	Gender
R1	Senior Lecturer	10	Business School	Extensive	In-person	Female
R2	Assistant Professor	5	Information Technology	Moderate	In-person	Male
R3	Associate Professor	12	Educational Technology	Extensive	In-person	Female
R4	Lecturer	3	Business School	Basic	In-person	Male
R5	Senior Lecturer	8	Business Administration	Moderate	In-person	Female
R6	Assistant Professor	6	Marketing	Moderate	In-person	Female
R7	Associate Professor	15	Management	Extensive	In-person	Male
R8	Senior Lecturer	9	Business Analytics	Moderate	In-person	Female
R9	Lecturer	4	Business School	Basic	In-person	Male
R10	Senior Lecturer	11	Business Communication	Extensive	In-person	Female
R11	Assistant Professor	7	Entrepreneurship	Moderate	In-person	Male
R12	Associate Professor	13	Information Systems	Extensive	In-person	Female
R13	Lecturer	2	Business School	Basic	In-person	Female
R14	Senior Lecturer	9	Organizational Behaviour	Moderate	In-person	Male
R15	Assistant Professor	5	Business Ethics	Moderate	In-person	Female
R16	Associate Professor	14	Finance	Extensive	In-person	Male
R17	Senior Lecturer	10	Human Resource Management	Extensive	In-person	Female
R18	Lecturer	3	Business School	Basic	In-person	Male

Data Collection

Data was collected to explore the impact of VR on immersive education and classroom dynamics through semi-structured interviews (Table 2). This qualitative approach enabled a focused yet adaptable investigation of participants' perspectives, allowing the researcher to address specific issues while uncovering unexpected connections. In-

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person interviews were particularly beneficial, as they encouraged participants to openly express their views, ensuring authenticity in their responses. Nonverbal cues, such as body language, provided additional context to the verbal feedback (Hollstein & Kumkar, 2021). Each interview lasted between 45 and 60 minutes, during which participants remained attentive and engaged throughout the process.

Table 2: Interview Protocol

Variable	Interview Questions
Experience with VR Technology	How long have you been using VR technology in your teaching?
	Can you describe your initial experience with VR in the classroom?
	What challenges have you encountered while using VR technology?
Impact on Teaching Effectiveness	How has VR technology affected your teaching methods?
	In what ways do you feel VR has enhanced or hindered your teaching effectiveness?
	Can you provide examples where VR technology improved the learning outcomes of your students?
Student Engagement	How do students typically respond to VR-based lessons compared to traditional methods?
	What changes in student engagement have you observed when using VR in the classroom?
	Can you share any specific instances where VR technology significantly increased or decreased student participation?
Challenges and Barriers	What technical issues have you faced when implementing VR in your courses?
	How do you address students' difficulties or discomfort with using VR technology?
	What institutional or resource-related challenges have you encountered in integrating VR into your teaching?
Perceived Benefits	What do you see as the primary benefits of using VR in your teaching?
	How has VR contributed to the overall learning experience of your students?
	In what ways do you believe VR has the potential to transform education in your field?
Future of VR in Education	How do you envision the future of VR in education, particularly in your discipline?
	What improvements or changes would you like to see in VR technology to better support teaching and learning?
	Do you plan to continue or expand your use of VR in the future? Why or why not?

Before the interviews, participants were contacted to confirm their availability and provide an overview of the study's aims and topics. This pre-interview

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communication was crucial in preparing participants and ensuring they understood their role in the study. Each participant was informed about the study's objectives and the value of their input. To ensure accuracy, digital audio recorders were used to capture the full conversation, including participants' nuanced language and emotions. This allowed the researcher to focus on the dialogue rather than note-taking, fostering a more natural and uninterrupted exchange of ideas (Braun & Clarke, 2021). The recorded interviews were transcribed verbatim to create a comprehensive record for data analysis, preserving all relevant information for qualitative research.

Confidentiality was strictly maintained throughout the data collection process. Participants were assured that their identities and responses would remain anonymous. A safe, trustworthy environment was established, encouraging participants to speak freely without fear of repercussions. Informed consent was obtained before each interview, explaining the study's goals, data collection methods, and participant rights, including the right to withdraw without penalty. Participants were given the opportunity to ask questions and voice concerns before signing the consent form. The researcher remained flexible with interview questions, allowing for the exploration of complex themes while ensuring the research aims were met. The analysis of the interviews, particularly regarding immersive education and the impact of virtual reality on classroom dynamics, informed the study's findings.

Data Analysis

This study employed thematic analysis, a qualitative approach known for its flexibility and ability to uncover complex patterns in data (Braun & Clarke, 2006), to explore how VR influences classroom dynamics and immersive teaching, as revealed through semi-structured interviews. The process began with verbatim transcription of each interview, carefully noting tone, phrasing, and emotion, which is crucial in qualitative research to ensure engagement with the data rather than treating it mechanically (Goldsmith, 2021). Once transcribed, the researcher reviewed the transcripts multiple times to gain familiarity with the content and context, which facilitated theme construction and the identification of key topics. The data was then coded into smaller, meaningful segments, with a focus on annotating text relevant to the study's objectives, particularly participants' insights on the advantages, disadvantages, and challenges of VR integration in education (Saldaña, 2021). A flexible coding approach was adopted to allow categories to evolve as new insights emerged (Figure 1). Descriptive and interpretative categorisation was used to capture both the surface-level content and deeper, more nuanced patterns in the interviews, ensuring a comprehensive analysis of the data that explored both explicit and implicit meanings in the context of VR's impact on education.

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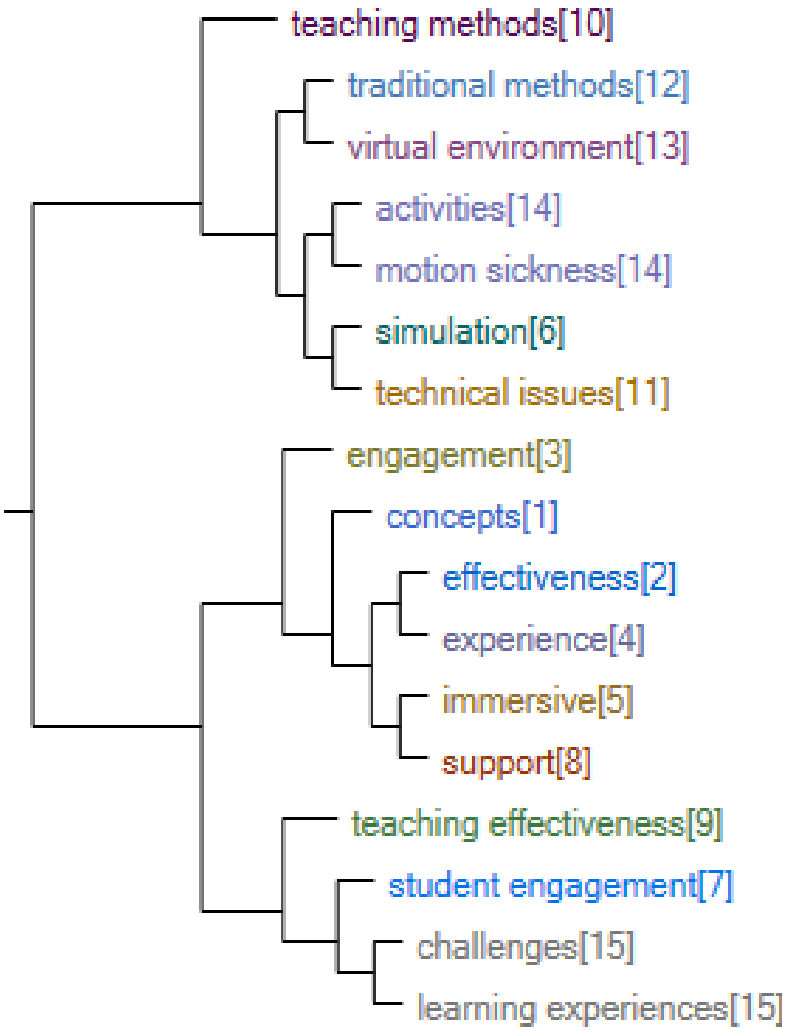

Figure 1: Cluster of Items for Coding

The researcher developed themes and sub-themes (Figure 2) after coding the data, focusing on identifying patterns and correlations within the data. Themes are meaning patterns that emerge from multiple codes with a shared focus (Braun & Clarke, 2021). The study revealed that VR technology enhances student engagement while presenting challenges for instructors. By analysing specific issues within each primary theme through sub-themes, the researcher gained a deeper understanding of the content. The next step involved refining concepts to align more closely with the reality of the data. A comprehensive theme characterisation required repeated examination of data and codes. The researcher ensured coherence by verifying that all data segments within a theme were logically connected and relevant. This process involved reorganising data segments or merging and splitting themes to highlight emerging patterns. Themes were cross-validated against the original data to ensure relevance and reliability. Data-driven themes were then verified by revisiting the interview transcripts to ensure they accurately reflected the participants' experiences and perspectives. The final themes addressed the research questions in a robust and insightful manner, demonstrating the impact of VR on classroom dynamics and immersive learning.

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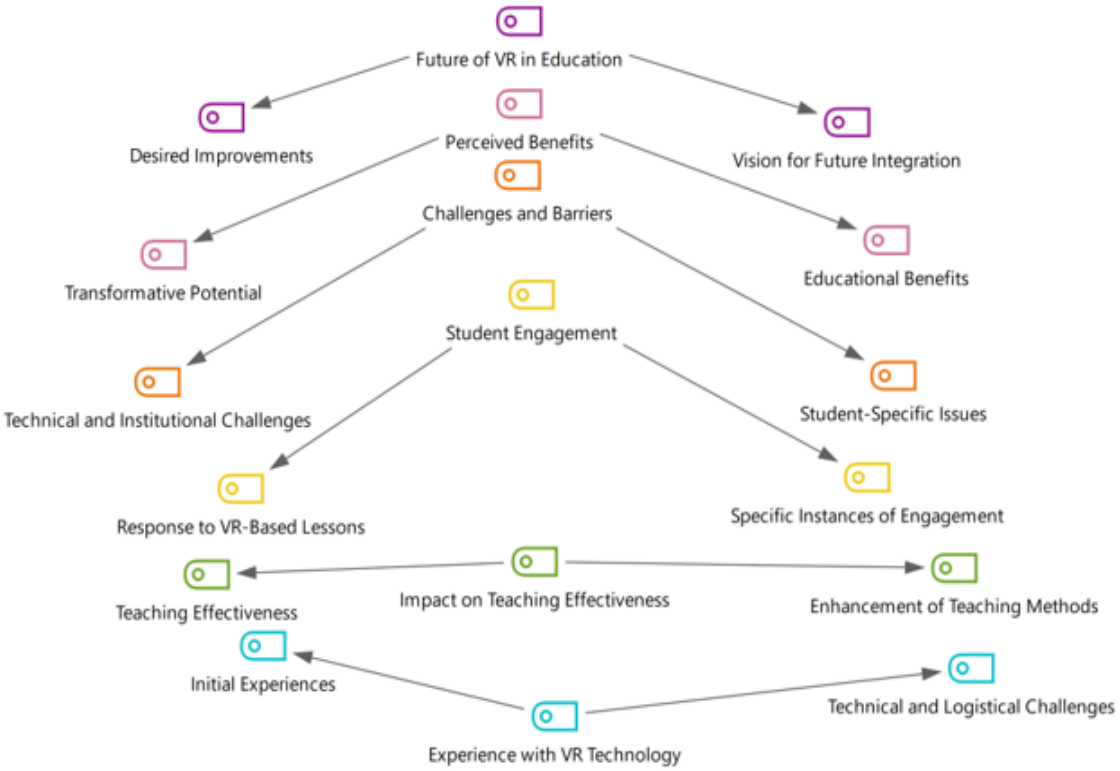

Figure 2: Themes and Sub-Themes Identified after Coding

Findings

Theme 1: Experience with VR Technology

Sub-theme 1.1: Duration and Initial Experience

The review of VR technology revealed that participants had varying experiences, with usage ranging from 10 to 18 months. Early VR users faced technical challenges, including installation issues and application compatibility, which hindered initial adoption (Adelana et al., 2023). Respondents, such as R1, highlighted that VR's benefits require time to fully grasp, while R6 mentioned encountering technical difficulties despite enthusiasm. Many participants, including R3 and R8, struggled with the learning curve and technical setup, echoing previous studies that suggest VR's complexity can impede its integration into education. However, despite these challenges, educators are gradually adopting VR, recognizing its potential to enhance teaching and learning. Respondent R10 noted that the early struggles were outweighed by the long-term benefits of using VR in education.

Sub-theme 1.2: Technical and Logistical Challenges

The study revealed that instructors face significant logistical and technological challenges when integrating VR technology into the classroom. These barriers—particularly those related to technology and logistics—highlight the role of VR in education. Key technical difficulties included issues with software, headset

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calibration, and connectivity (Figure 3). Several respondents, such as R4, experienced recurrent problems with headset calibration, which hindered students' immersive experience and required considerable trial and error to achieve the correct settings. This aligns with findings by Ford et al. (2023), who identified calibration and optimisation of VR equipment as problematic. Software issues also emerged as a major concern; for instance, R9 reported frequent software failures that led to delays, frustrating students and disrupting their learning, which is consistent with prior research emphasising the importance of software stability for effective VR use in education (Kadri et al., 2024). Connectivity problems were another barrier; R13 noted that system connectivity issues often disrupted sessions, requiring technical support to resolve, highlighting the need for a robust technological infrastructure for successful VR integration (Joshi et al., 2021). Logistical challenges also impeded the adoption of VR in classrooms. Several participants reported difficulties in installing VR equipment and ensuring students could access it. R5, for example, mentioned that setting up VR equipment for each session was time-consuming and disrupted teaching. Huber et al. (2022) similarly noted that educators are concerned about the practicalities of using VR in the classroom. Additionally, R11 noted that uneven distribution of VR equipment hindered group participation, further complicating the use of VR in educational settings. These logistical and technological obstacles must be addressed to optimise VR technology for immersive learning experiences.

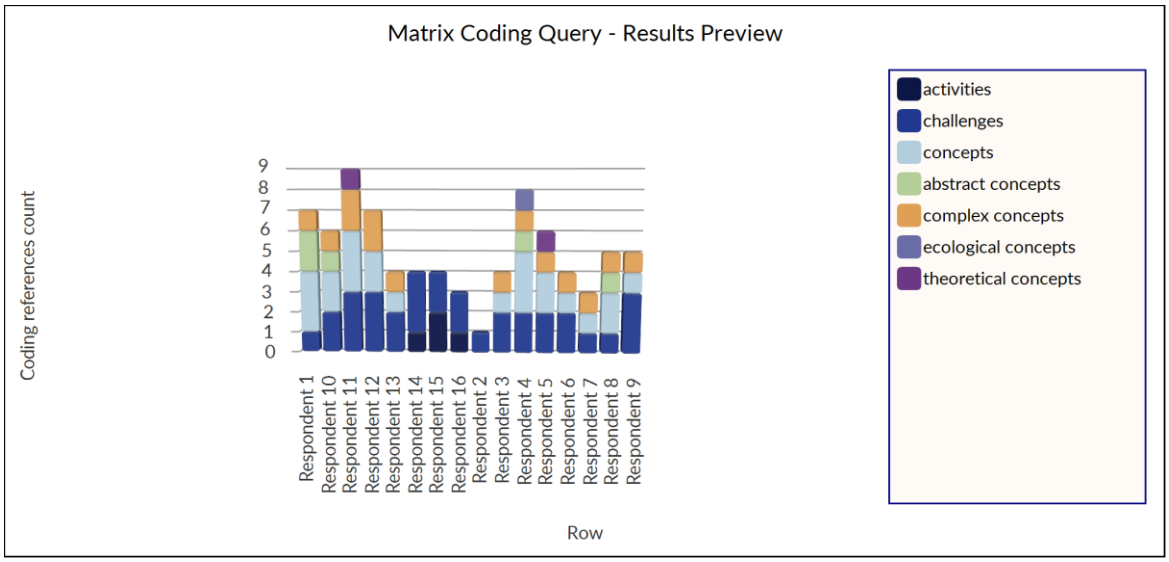

Figure 3: Weightage of Responses for Theme 1

Theme 2: Impact on Teaching Effectiveness

Sub-theme 2.1: Enhancement of Teaching Methods

The study highlights how VR can transform education by enhancing the understanding of complex concepts and providing immersive learning experiences (Figure 4). A key benefit identified was VR's ability to foster interactive learning, enabling professors to create engaging lessons that extend beyond traditional lecture

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methods. Respondent R7 noted that VR had changed their relationship with students, as conventional lectures lacked the participatory engagement that VR facilitates. This finding aligns with Hamilton et al. (2021), who highlighted VR's potential to support collaborative and participatory learning. By actively engaging with content in VR, students' recall and comprehension of complex concepts are significantly improved. Respondent R14 explained that VR helps students grasp challenging ideas, as the three-dimensional content offers a more interactive and visual way of learning. Similarly, R12 noted that before the introduction of VR, students struggled to understand abstract concepts, but with VR, they could visualise these ideas more clearly and engagingly. This finding supports research by Huber et al. (2022), which suggests that VR helps students better understand complicated topics. The study reinforces the idea that VR provides contextual and participatory experiences, which enhance student engagement and cognitive comprehension. These findings align with existing literature on the effectiveness of immersive, interactive learning environments in improving both understanding and memory.

Sub-theme 2.2: Teaching Effectiveness

This study found that VR increased student engagement in classrooms, enhancing teaching effectiveness. Respondents noted that VR's immersive environment boosted participation and interest. Respondent R8 observed a significant rise in student engagement, while R11 highlighted the captivating nature of VR lessons. Research supports these findings, indicating that immersive technologies, such as VR, enhance student involvement (Tellez et al., 2024). However, technical challenges and preparation time were major limitations. Respondent R4 noted that equipment faults, though rare, disrupted lessons, while R10 cited the time-consuming setup process as a barrier to effective teaching. These issues align with previous studies on the technological hurdles of VR integration in education (Chan et al., 2021). Addressing these challenges is crucial for maximizing VR's potential in educational settings.

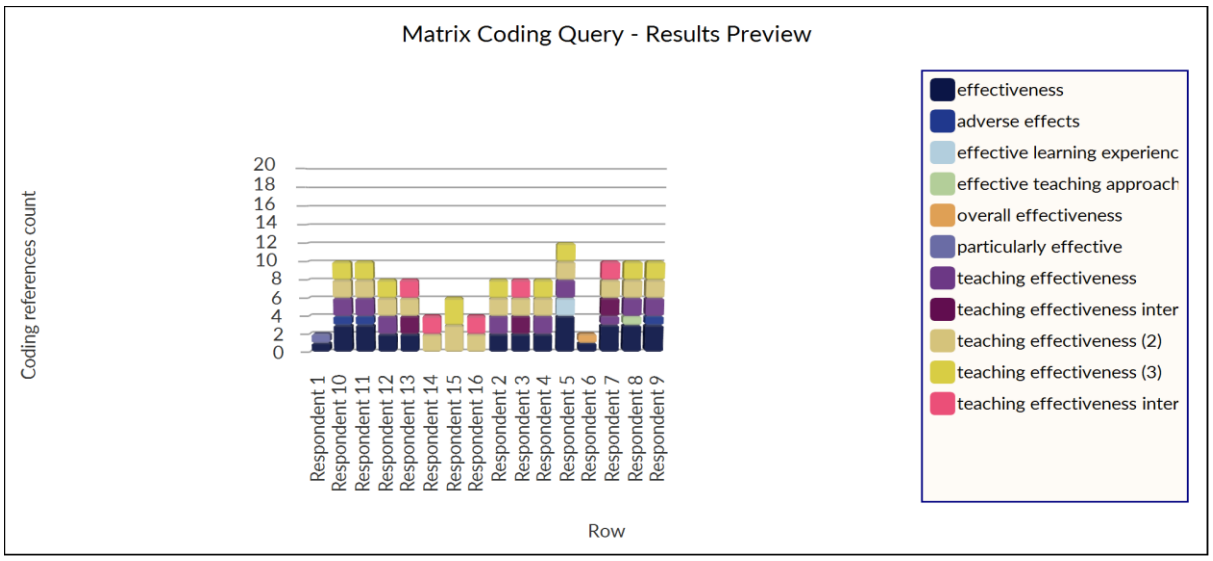

Figure 4: Weightage of Responses for Theme 2

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Theme 3: Student Engagement

Sub-theme 3.1: Response to VR-Based Lessons

The study indicates that VR technology significantly enhances course engagement, suggesting its potential to improve educational outcomes (Figure 5). Participants noted that students often preferred VR-based classes, finding them more engaging than traditional teaching methods. The immersive and interactive nature of VR appears to attract students, fostering a heightened enthusiasm for learning. Respondent R6 commented, "Students consistently exhibit enthusiasm towards VR lessons," highlighting the captivating nature of the VR experience compared to conventional lectures. This finding aligns with existing research, which shows that VR technology can create engaging and dynamic learning environments. The study also found that VR's interactive features contributed to increased student engagement. Respondent R8 observed a marked rise in student participation during VR lessons, noting that students were more motivated and actively involved. Similarly, Respondent R12 remarked that VR sessions were particularly captivating, with students showing greater enthusiasm and motivation. These findings support the notion that immersive technologies, such as VR, can enhance student engagement and enthusiasm in educational settings (Hara et al., 2021).

Sub-theme 3.2: Specific Instances of Engagement

The study's analysis of individual VR engagements highlights both student anxiety and increased participation in VR-based courses. These findings demonstrate the impact of VR on student engagement, as well as the strategies educators employ to address associated challenges. Interactive simulations and virtual field trips were identified as key factors in enhancing student engagement. Respondent R9 noted that virtual field trips were particularly effective, as students were more engaged in unfamiliar environments when using VR, compared to traditional classroom field trips. This supports the idea that VR can offer immersive learning experiences that captivate students (Lan et al., 2024). Additionally, interactive simulations were found to enhance engagement by providing hands-on, collaborative learning opportunities. Respondent R11 emphasised that these simulations help students engage with complex concepts, as they can test hypotheses and observe live results. However, some respondents, such as R5, noted that extended VR sessions led to physical discomfort, including nausea. To address this, shorter VR sessions and alternative activities were recommended to optimise engagement. The study suggests that integrating traditional educational methods with brief VR sessions can mitigate these issues and promote inclusion. Moreover, the study found that teachers must recognise and adapt to students' physiological responses to VR in order to maximise learning and engagement. Respondent R13 explored strategies to maintain lesson effectiveness without compromising student comfort.

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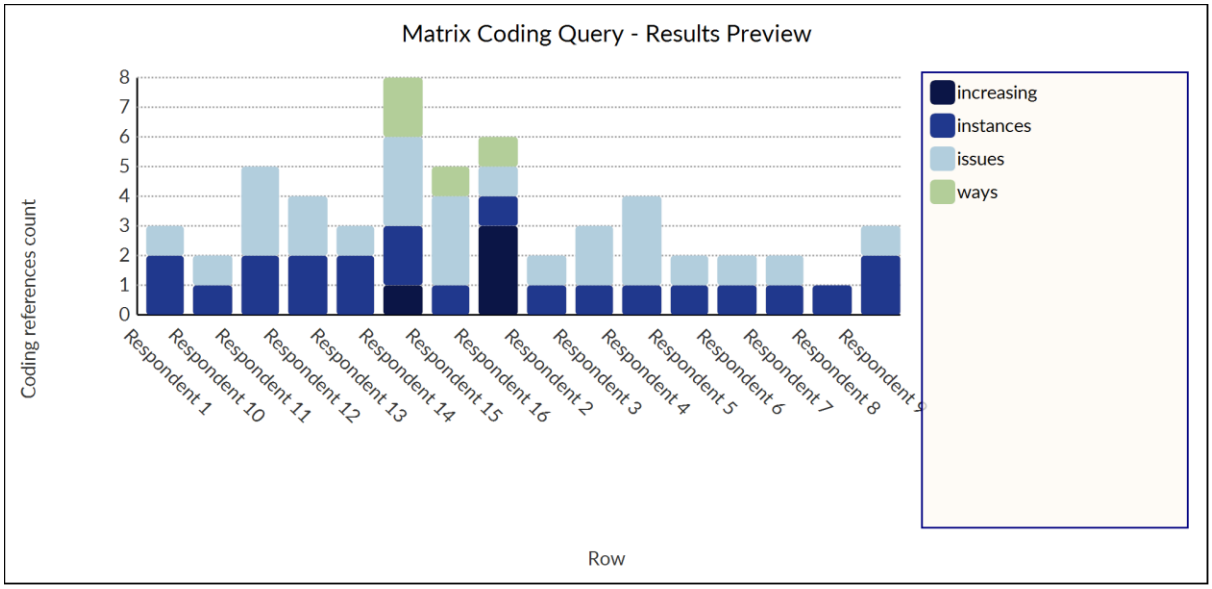

Figure 5: Weightage of Responses for Theme 3

Theme 4: Challenges and Barriers

Sub-theme 4.1: Technical and Institutional Challenges

The study identified significant technological and institutional barriers to VR adoption in education, including headset calibration, software malfunctions, and connectivity issues (Figure 6). Respondent R7 highlighted that headset calibration and setup delays disrupt VR sessions, while other respondents noted that equipment design and software failures affect course flow. Connectivity issues, as reported by R3, further interrupted VR sessions, reducing the effectiveness of VR in the classroom. These challenges underscore the need for reliable, user-friendly technology to facilitate effective VR integration, supporting previous research on the impact of technical barriers on VR adoption in education (Adelana et al., 2023). For the successful integration of VR into the classroom, several technological and institutional challenges must be addressed. A key concern highlighted by respondents was the lack of institutional support, particularly regarding funding and approval for VR implementation. Respondent R10 noted that securing financial resources for VR equipment and programming has been challenging, with insufficient funding hindering both the acquisition and maintenance of VR technologies. This issue is consistent with previous research, which suggests that financial constraints can limit the development and adoption of VR curricula. Additionally, obtaining institutional approval for VR integration proved to be time-consuming, as noted by Respondent R12, who described difficulties in gaining administrative clearance to incorporate VR into the curriculum. Bureaucratic resistance and the absence of clear policies and guidelines further complicate the process of technology adoption. Therefore, overcoming these technological and institutional barriers requires comprehensive solutions that involve sustained financial investment, institutional backing, and regulatory approval (Lan et al., 2024). Effective VR integration in education also

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necessitates ongoing technical support and staff training to ensure its successful deployment and use.

Sub-theme 4.2: Student-Specific Issues

The study explored strategies to reduce student anxiety and discomfort in VR-based education. Respondents reported that VR can induce motion sickness and other physical ailments, particularly for students sensitive to immersive environments. For instance, R14 noted that long-term VR use made some students feel nauseous. To address these issues, teachers implemented several approaches, including providing clear instructions on VR usage and potential health impacts (R8). This proactive support helped students feel more comfortable and prepared. Additionally, alternative activities were offered to students who experienced discomfort with VR, ensuring inclusivity and participation for all learners (R2). These strategies align with principles of inclusive learning, allowing students who cannot fully engage with VR to still participate in lessons (Hamilton et al., 2021). Instructors can enhance student engagement and accommodate diverse needs by providing alternative learning options. To mitigate student discomfort, adjustments were made to the length and intensity of VR sessions. Respondent R11 suggested that shorter VR sessions were more effective in reducing motion sickness, noting that breaks were also incorporated to help students adjust and alleviate discomfort. Such modifications to session duration and the inclusion of rest periods can enhance the effectiveness of VR-based learning while minimising its physical side effects (Lan et al., 2024).

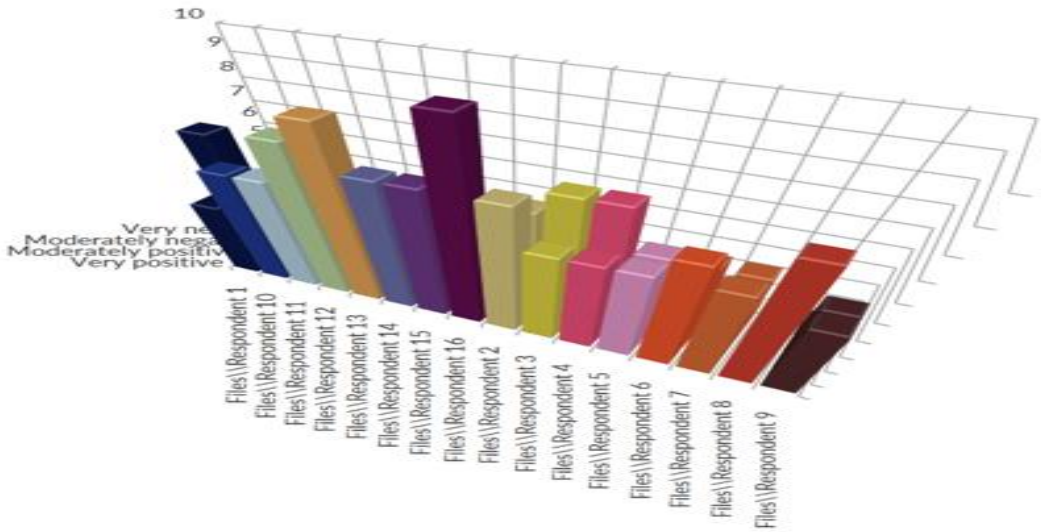

Figure 6: Weightage of Responses for Theme 4

Theme 5: Perceived Benefits

Sub-theme 5.1: Educational Benefits

VR technology has been demonstrated to enhance student engagement and facilitate the understanding of complex topics, offering significant potential for transforming

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education (Figure 7). One of the key educational benefits identified was increased student enthusiasm and participation. Respondent R9 noted that VR has significantly boosted student engagement in their classes, with interactive features and immersive environments capturing students' attention more effectively than traditional teaching methods. VR's immersive nature enhances student motivation and involvement in learning, as highlighted by Respondent R13, who observed that students are more willing to explore virtual environments, leading to improved engagement and retention. Additionally, Respondent R5 reported that three-dimensional learning aids students in comprehending difficult concepts. Respondent R8 further emphasised that VR assists in helping students grasp and retain complex subjects, such as molecular biology and historical events. This study underscores VR's ability to simplify complex topics and enhance learning outcomes.

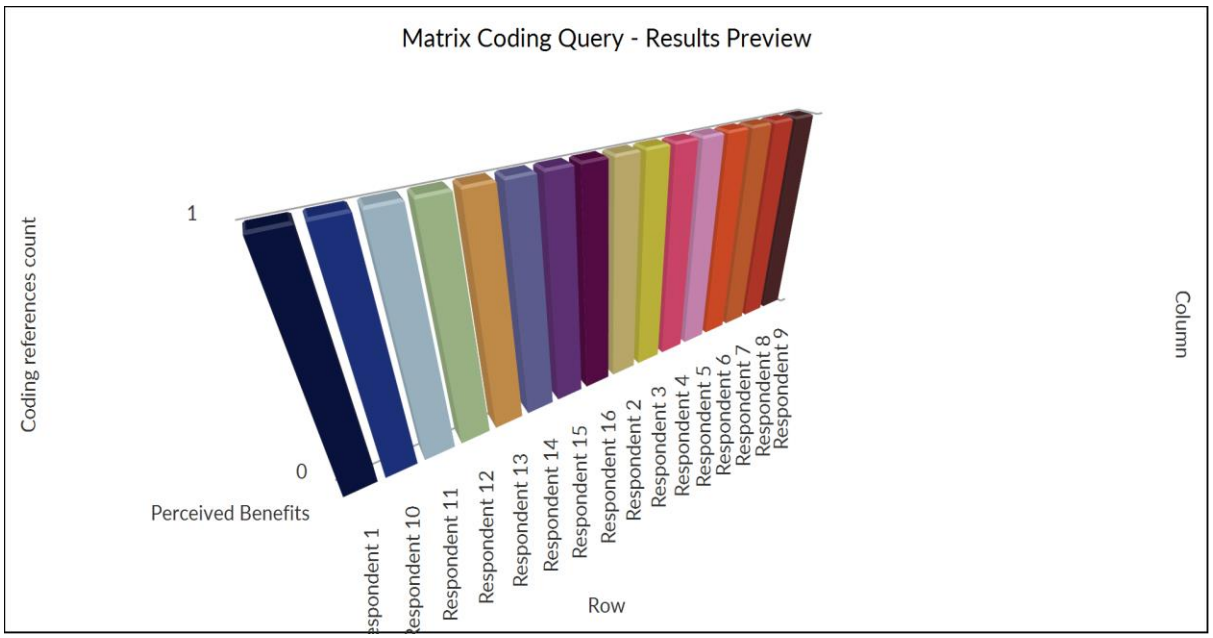

Figure 7: Weightage of Responses for Theme 5

Sub-theme 5.2: Transformative Potential

VR has the potential to transform education by offering unique learning opportunities and enhancing learning efficiency. Survey respondents believe that VR can improve engagement and learning outcomes by creating interactive and immersive environments. However, the high cost of VR technology remains a significant barrier to its widespread adoption in education. To facilitate greater integration, respondents recommend reducing costs, enhancing content specialization, and developing educationally relevant material (Goh & Sandars, 2020). Additionally, many educational sectors face a shortage of expert VR resources, underscoring the importance of integrating VR into existing teaching methods and technologies. Respondents highlighted the need for seamless integration of VR with educational tools and processes to maximise its effectiveness. Rather than replacing traditional methods, VR should complement them, enhancing the overall educational experience.

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Theme 6: Future of VR in Education

Sub-theme 6.1: Vision for Future Integration

Participants expressed strong enthusiasm for expanding VR use in education and anticipation for future technological advancements, recognising its transformative potential (Figure 8). Respondents highlighted the positive impact of VR on student engagement and learning outcomes, with many eager to integrate it further into their teaching methods. Respondent R4, for example, expressed plans to increase VR utilisation in their courses, citing the positive student response and heightened engagement as compelling reasons for doing so. This aligns with research by Wagener et al. (2021), which underscores VR's ability to create captivating and immersive learning experiences. Respondent R10 also noted the positive impact of VR on education, with plans to explore its integration across other curriculum areas. These insights support the view that VR has the potential to reshape education by enhancing student engagement and knowledge retention Yin et al. (2023). Respondents were also optimistic about the future of VR technology, with many anticipating that advances will further enhance its effectiveness in teaching. Respondent R6, in particular, looked forward to improvements in immersion and engagement, believing that future technological developments will significantly benefit both teaching and student involvement.

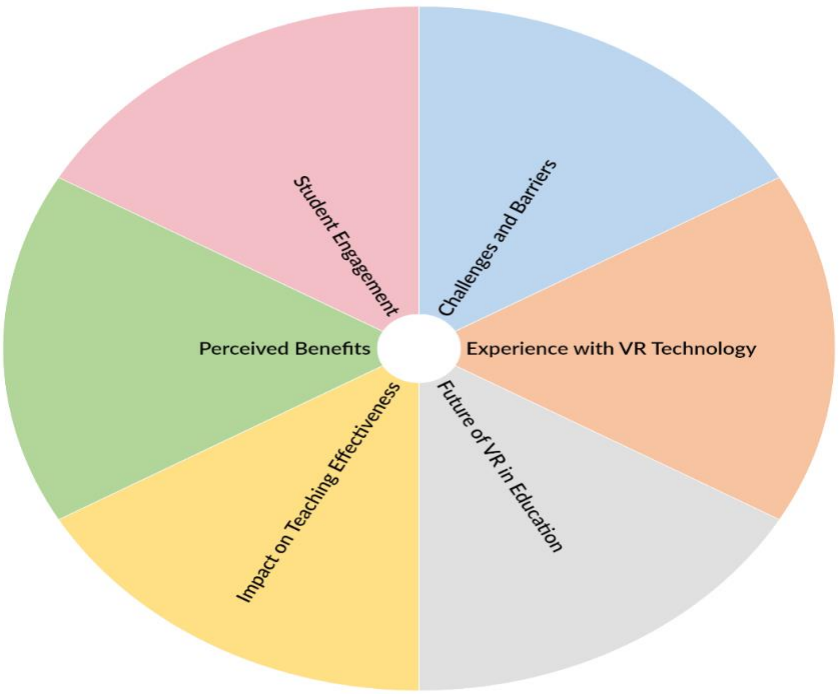

Figure 8: Distribution of Themes in Clusters

Sub-theme 6.2: Desired Improvements

The research highlights the challenges of integrating VR into education, particularly regarding its effectiveness and the barriers to widespread adoption (Kadri et al., 2024).

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Respondents raised concerns about the high cost, limited availability, and lack of relevant content, all of which hinder the integration of VR into existing teaching methods. Respondent R2 noted that the high cost of VR technology restricts its use, with many institutions unable to afford the equipment despite its potential benefits. To encourage broader adoption, R8 suggested that reducing costs and improving accessibility would make VR more feasible for educational institutions. Additionally, R11 highlighted the need for more instructional content tailored to educational and disciplinary standards, as much of the existing VR content does not align with these requirements. Respondent R15 further emphasised the challenge of integrating VR with traditional teaching approaches, suggesting that effective integration would require the development of advanced tools and frameworks.

Discussion

The study provides valuable insights into the integration of VR in education, examining its impact on teaching effectiveness, student engagement, and the associated challenges and benefits. It addresses key research questions regarding how VR influences teaching methods, the effectiveness of immersive learning, and the overall student experience. The findings reveal that instructors' experiences with VR technology varied, with comfort levels and initial challenges differing across participants. Over a period of 10 to 18 months, instructors used VR to enhance their teaching, demonstrating both their growing competence and enthusiasm. This fluctuation highlights that educators' VR skills and acceptance are central to its successful integration. While early experiences with VR in education were hindered by technical issues, such as software malfunctions and headset calibration problems, these challenges underscore the need for instructors to develop the necessary technical expertise to effectively troubleshoot and utilise VR technology in the classroom (Figure 9).

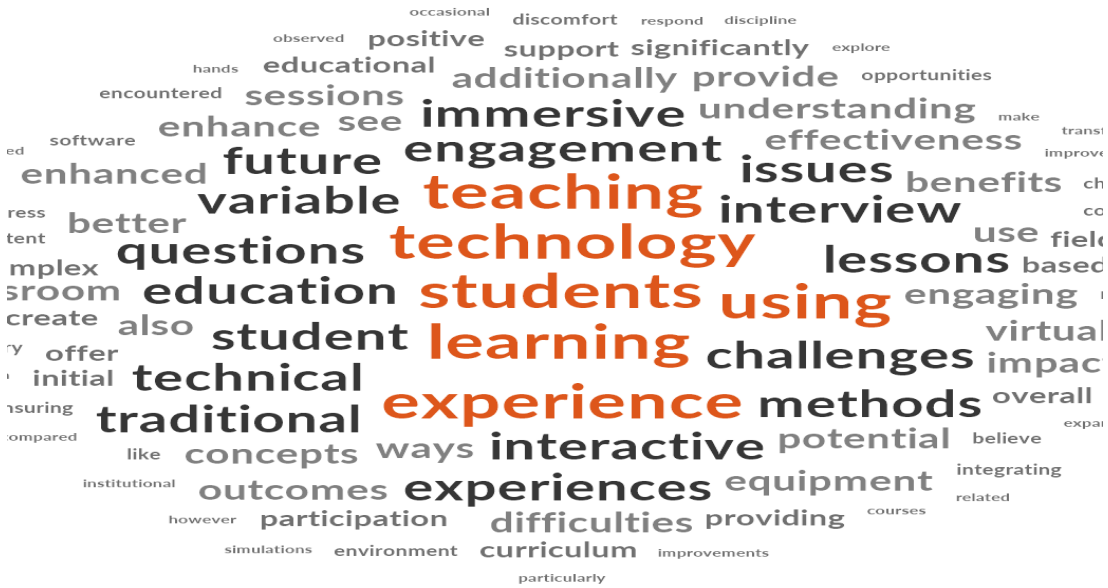

Figure 9: Word Cloud of the Document

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The study highlights the challenges of integrating VR into education, aligning with recent research on the difficulties of instructional technology adoption (van Hooijdonk et al., 2022). Overcoming initial technical issues, such as software glitches and headset malfunctions, is crucial for the effective use of VR in education. These challenges require problem-solving and additional training for educators. Despite these obstacles, VR's interactive and immersive features have been shown to enhance student engagement and comprehension, particularly in complex subjects (Kadri et al., 2024). VR's experiential learning opportunities, such as simulations, have proven more effective in helping students understand difficult concepts than traditional rote learning. However, the potential of VR in education remains limited by technical disruptions and the considerable time required to develop and implement VR-based lessons. The need for extensive preparation and troubleshooting may slow the widespread adoption of VR. This underscores the importance of reliable technology, support systems, and sufficient preparation time to fully leverage VR's educational benefits. Balancing the time required for VR course development with its potential advantages is essential for maximizing its effectiveness in the classroom.

The research underscores the transformative potential of VR in education, highlighting its ability to engage students more effectively than traditional teaching methods. This aligns with existing literature showing that VR can enhance student engagement and participation (Mutua et al., 2023). The immersive nature of VR fosters a more interactive and participatory learning environment compared to passive traditional instruction. However, despite these positive outcomes, some students experienced anxiety, including motion sickness, which limited their full participation in VR sessions. This finding validates concerns in the literature regarding the physical discomfort associated with VR technology (Wagener et al., 2021). To mitigate these issues, it is crucial to shorten VR sessions, provide clear instructions, or offer alternative tasks, ensuring an inclusive learning environment. These strategies are essential to maximize the benefits of VR while addressing its potential drawbacks. Despite its promise, the integration of VR into education is hindered by several practical challenges, including technical issues such as software malfunctions and headset calibration problems (Chan et al., 2023). Moreover, institutional barriers such as financial constraints and the need for administrative approval further complicate VR adoption. Overcoming these challenges requires collaboration to secure institutional support, funding, and resources necessary for successful VR integration in educational settings. This study highlights the importance of addressing these barriers to fully realise VR's educational potential.

The integration of VR in education faces challenges, including technical issues like headset calibration and software glitches, which can disrupt learning (Lei et al., 2022). Additionally, institutional barriers such as financial constraints and the need for approval can hinder VR adoption (Wang & Yan, 2019). Despite these obstacles, VR has the potential to enhance student engagement and understanding of complex topics by

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providing immersive, interactive learning experiences (Stucki et al., 2024). Overcoming these technical and institutional challenges is essential for maximising VR's educational benefits, making it a worthwhile investment for improving learning outcomes.

Conclusion

This study highlights both the advantages and challenges of using VR in education. VR has the potential to significantly enhance student engagement and instructional effectiveness by providing immersive learning experiences that help clarify complex concepts. Research indicates that VR surpasses traditional teaching methods in fostering dynamic and engaging learning environments, leading to better understanding and retention of difficult topics. However, technical issues such as software bugs, headset calibration, and connectivity problems were prevalent, disrupting learning and limiting VR's instructional value. Additionally, securing institutional support and funding remains a major challenge for widespread VR adoption in education. Despite these barriers, the study confirms that VR can effectively engage students, as reflected in positive responses and increased engagement from participants. The findings underscore the need for continuous innovation and technical support, including improvements in VR content, affordability, and accessibility. To fully realise VR's potential in education, these challenges must be addressed. This report provides valuable insights for policymakers, administrators, and educators on how to harness VR's transformative power, suggesting that overcoming these limitations is crucial for its successful integration.

Theoretical and Practical Implications

The study's conclusions on immersive VR instruction have significant implications for educators, institutions, students, and policymakers. It highlights VR's potential to enhance education by offering immersive and engaging learning experiences that help explain complex concepts, making learning more interactive and enjoyable. To fully leverage these benefits, instructors must integrate VR into their teaching methods. However, challenges such as software glitches and headset calibration require institutional resources and expertise. Professional development and training programs are essential to help educators overcome these obstacles and maximise VR's technological advantages. The study also underscores the critical role of educational institutions in VR adoption, emphasizing the need for institutional support to address financial and regulatory barriers. Institutions must build robust support systems, and policies should actively encourage the use of cutting-edge technologies by providing the necessary financial resources, technical assistance, and infrastructure to advance VR in education.

The study demonstrates that students benefit significantly from immersive VR

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experiences, with VR shown to engage learners and make education more interactive. Regardless of socioeconomic or physical status, all students should have access to VR, and educational institutions should prioritise its integration. The findings provide valuable insights for educational leaders and policymakers, guiding decisions related to technology adoption and innovation. Emphasising VR and personalised education, the research calls for government support in advancing VR research and development. Policies enabling the distribution and funding of educational technology are critical for overcoming barriers and improving VR integration. To fully harness the potential of VR, successful integration requires collaboration from all stakeholders. Institutions must provide necessary support and resources, educators must be well-trained, and policymakers must foster an environment conducive to innovation and accessibility. Addressing these challenges will enable educators to effectively use VR to enhance teaching and learning outcomes.

Limitations and Future Directions

This research explores immersive teaching with VR, though it has limitations. The study primarily involves a small sample of VR educators, which restricts its generalisability. A broader sample, including teachers from various disciplines, educational levels, and regions, would offer a more comprehensive understanding of VR's potential and challenges in education. The study's reliance on semi-structured qualitative interviews may have been influenced by interviewer biases, and future research could benefit from a mixed-methods approach combining quantitative surveys and qualitative interviews to improve reliability and precision. A longitudinal study could also examine how VR evolves in education over time. Another limitation is the study's focus on technological and administrative challenges, without exploring VR's cognitive and emotional effects on students. Future research should investigate how VR impacts students' cognitive abilities, emotions, and well-being to create more effective VR-based learning experiences. Additionally, the study highlights the importance of content specialization and cost-effectiveness in VR technology but does not delve into how these issues are addressed in practice. Future studies should explore these technological advancements across different educational contexts. Collaboration among educators, technology developers, and content creators will be key to advancing VR education. Finally, the study did not consider the ethical implications of VR in education, such as privacy, data security, and discomfort. These issues should be addressed in future research to ensure responsible and equitable use of VR in educational settings.

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