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Immersive Virtual Reality (IVR) Systems for Comprehensive Fire Safety Education in Primary School

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Abstract

In the evolving landscape of educational technology, immersive virtual reality (IVR) has emerged as a promising tool to enhance safety education for primary school students. Traditional fire safety methods, while foundational, face challenges in engaging young learners actively. This study aims to comprehensively investigate the intricate dynamics of integrating IVR technology into fire safety education for primary school students. By examining students' perceptions, assessing engagement levels, and evaluating learning outcomes, the research seeks to offer nuanced insights into the potential benefits and challenges associated with VR-based safety education. Conducted as a qualitative study, 25 semi-structured interviews were performed with primary school students (Grades 4-6 in China), employing a three-step thematic analysis. The research explores students' experiences with IVR fire safety simulations, comparing them with traditional methods, and addressing practical considerations for integration. Preliminary findings suggest positive perceptions, heightened engagement, and improved learning outcomes among students exposed to VR simulations. Practical challenges, including logistical considerations, were identified. The comparison with traditional methods illuminated strengths and weaknesses, guiding educators and policymakers. This research contributes to the intersection of education and technology by offering novel insights into the potential of IVR simulations in fire safety education. The study's significance lies in informing pedagogical practices, addressing practical challenges, and promoting safety awareness among primary school students, guiding future educational technology initiatives.

Keywords: Immersive Virtual Reality, Fire Safety Education, Educational Technology, Experiential Learning.

1 Introduction

Fire safety education prepares individuals for calamities. VR is an innovative way to teach crucial ideas. This study analyzes how IVR fire safety simulations affect students' learning and attitudes. VR treatment

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safety must be examined as education technology advances (Brahma et al., 2023). Immersive technology and teaching might transform elementary school fire safety curricula. Safety education has traditionally employed proven methods, but restricting instruction requires ingenuity. Students learn actively with realistic VR simulators. Simulated events allow students to experience actual events safely (Ono et al., 2024). Add fire safety drills to VR to boost students' safety awareness, preparation, and memory. The study uses immersive technologies and educational methodologies. Kang & Lee, (2020) examined how VR affects history, physics, mathematics, and culture. These studies show that VR experiences excite, engage, and retain pupils. Menzemer et al., (2023) evaluate elementary school fire safety teaching. Immersive experiences affect academic performance, according to education psychology. The engagement hypothesis states that interactive and immersive learning environments boost cognition and retention (Shokouhi et al., 2020). The cognitive load theory emphasizes mental effort-regulated learning. IVR experiences improve cognition and learning (Scorgie et al., 2024).

VR in education has been extensively studied, showing its merits and downsides. Educational technology research shows that immersive experiences boost student engagement and learning (Babalola et al., 2023). Virtual reality's capacity to construct hypothetical events and settings may help students grasp and remember professional topics. Traditional teaching methods dominate fire safety education research. These studies evaluated classroom lectures, printed materials, and conventional techniques for fire protection. Safety training is still important, but technology enables IVR simulations (Scorgie et al., 2024). IVR fire safety training research is few but fascinating. Early research suggests that VR simulations might increase students' fire safety knowledge by providing authentic and engaging learning experiences (Shokouhi et al., 2020). Immersive interventions offer a dynamic alternative to traditional schooling using sensory and spatial learning (Brahma et al., 2023). This study did not analyze the complicated relationships between students' perspectives, engagement, and IVR fire safety instruction results. Elementary school fire safety content is weak despite advances in IVR technology for training (Grabowski, 2021). The intricate links between students' involvement, perceptions, and learning outcomes in IVR fire safety simulations have not been studied. Virtual reality therapy for young learners needs further research despite promising results. Little research has examined how to integrate IVR technology into elementary school courses. Logistics including equipment shortages, teacher training, and technical assistance are understudied. Many practical challenges must be overcome to produce scalable and sustainable elementary school virtual reality technology.

By collecting empirical data beyond the first exploratory findings, this project will fill these research gaps. By studying how students use IVR fire prevention simulations, this study fills a gap in the academic literature. This will deepen our understanding of VR's safety training potential. This research examines virtual reality integration difficulties to advise IT corporations, decision-makers, and educators. The main goal of this study is to examine how IVR fire safety simulations affect elementary school pupils. This research examines the challenging dynamics of incorporating VR technology into youth fire safety teaching. It will analyze students' viewpoints, engagement, and learning results in several dimensions. This project's IVR fire safety simulation research should benefit policymakers, educators, and scholars. This study examines fire safety using IVR simulations, contributing to the emerging field of education-technology research. This study explores how virtual reality technology may improve safety training, expanding educational technology research and revealing the value of immersive learning settings. The findings of this study may affect elementary school instruction. Understanding how young pupils interact with virtual reality fire safety scenarios might help educators meet their needs. This research can assist teachers in finding new safety teaching strategies.

2 Literature Review

IVR technology is being utilized to improve education in many fields. Diverse businesses are using IVR technology to boost learning. Williams et al., (2020) state that engineering, healthcare, military training, and cultural preservation are studying VR. VR provides customers with an immersive environment for realistic learning activities. VR may immerse learners in dynamic and lifelike surroundings, allowing them to explore subjects and gain experiences beyond their physical reach (Babalola et al., 2023). Student learning and retention improve with VR study. VR's diversified interaction may improve kinesthetic and visual learners. VR technology helps students learn and gives educators and instructional designers new, engaging ways to create educational materials. Due to their adaptability, VR environments provide tailored learning that meets educational goals (Zhou, 2021). Interactive simulations, gamified situations, and virtual laboratories can boost student engagement and problem-solving. Virtual reality lets teachers and students work together remotely. VR revolutionizes remote education by creating immersive and interactive environments that enhance collaboration between teachers and students. VR facilitates virtual classrooms where participants feel present and engaged, supports hands-on learning through realistic simulations, and allows real-time interaction for discussions and group projects (Brahma et al., 2023). This technology also enables personalized learning by adapting to individual needs, offers global access to high-quality education, and includes virtual field trips that provide contextual learning experiences. By overcoming physical barriers and enhancing social interactions, VR significantly improves the quality and accessibility of remote education. Collaboration areas promote communication, socializing, and student community building. VR technology may change schooling and enhance dynamic and engaging training.

Perceptions of IVR

The study evaluated how students use and interpret IVR technology in education. As virtual reality apps become more popular in education, it's crucial to get students' feedback to improve their use. Fresh and engaging VR experiences engage and focus pupils. Huang et al., (2023) say VR allows pupils to experience virtual environments. This immersive environment makes students feel present and in command, improving learning attitudes. Teachers must understand these perspectives to maximize VR utilization in the classroom (Figure 1). Students view IVR based on past experiences and technological expertise. According to Hara et al., (2021), students with more digital technology exposure are more comfortable and enthusiastic about virtual reality instruction. Beginners may take time to acclimate to virtual world engagement. Researchers and educators must include students' technical experiences while exploring IVR in education. Virtual reality content's educational aims and intrinsic attributes also influence students' impressions. According to (Wang & Cai 2023), students are more likely to utilize VR applications that provide useful and engaging information and promote education. VR experiences are brief, thus new technologies must be properly integrated and acceptable for teaching. VR material's relevance to real-world situations may engage and educate students, boosting their technological attitudes (Brahma et al., 2023). VR material must be carefully chosen by educators to include in education. Student interactions about IVR may yield insights. Focus groups and interviews can help researchers understand students' VR experiences by capturing their feelings, preferences, and concerns. Gomez-Tone et al., (2023) found that students' perceptions of VR simulations' authenticity and impact on learning reveal their participation. Understanding VR's emotions—envy, curiosity, and concern—may help us understand its sensory aspects. Positive impressions of IVR are connected to student engagement, but educators must also address student concerns. Motion sickness, discomfort, and

technological concerns may impair students' VR app ratings (Kim et al., 2020). Addressing these issues and adapting virtual reality experiences based on student input is crucial to maintaining interest and positivity. Cognitive kinds and learning preferences affect students' VR technology immersion.

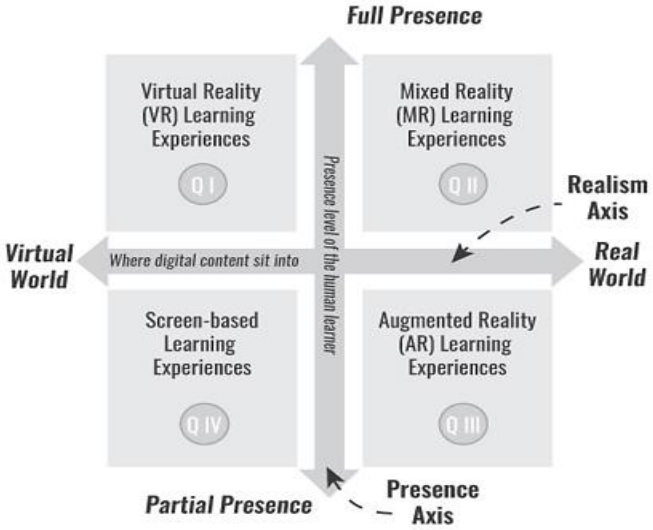

Figure 1: Immersive Learning Quadrant (Source: https://aieaworkshops.org/immersive-learning-quadrant-how-to-classify-understand-technologies/)

Current State of Fire Safety Education

Fire safety education strengthens readiness and protects children and staff. Curriculum, instruction, and new technology alter present techniques' efficacy. Many elementary schools teach fire safety through lectures, demonstrations, and writing. These methods are effective depending on instructional resources, teacher skills, and student involvement (Wu et al., 2023). Creative ways that engage young kids and deepen fire safety understanding are becoming increasingly important. Technology like online tools and interactive multimedia presentations are improving fire safety education (Noh & Park, 2022). Digital technology can help people remember safety information through visuals and interactivity. However, factors like technological availability, teacher training, and curriculum focus affect how much these technologies are employed in elementary schools. To use technology for fire safety education, fair access to technology and internet access must be prioritized. Despite efforts to enhance fire safety training, primary schools struggle to harmonize processes. Primary schools struggle to manage processes relevant to fire safety education due to several challenges. These include limited access to modern technology and the internet, which hinders the implementation of advanced training tools like virtual simulations (Nakum et al., 2022). Additionally, there is often a lack of standardized curricula and resources, leading to inconsistent training quality. Schools may also face difficulties in scheduling regular fire drills and integrating fire safety education into an already crowded curriculum (Grabowski, 2021). Budget constraints can further limit the ability to acquire necessary equipment and materials. Lastly, ensuring that all staff are adequately trained and up-to-date with the latest fire safety protocols can be a logistical challenge (Kwegyir-Afful, 2022). Students' preparation might vary depending on fire safety instruction content and difficulty. Fire safety education is further hindered by the curriculum's short duration (Nakum et al., 2022). Engaging people in fire safety discussions is tough and requires ongoing evaluation and development. Fire safety education today needs cultural and contextual elements. Regional limits,

community norms, and cultural risk perceptions impact schooling. Students receive relevant and meaningful fire safety instruction locally, improving the possibility of adoption (Kwegyir-Afful, 2022). Cultural diversity must be accepted to build community loyalty and accountability. New research evaluated how VR and other immersive technologies may improve elementary school fire safety instruction (Grabowski, 2021). VR simulations provide students with a realistic and interesting way to practice safety in a controlled setting (Grabowski, 2021). VR technology in fire safety instruction appears to improve student retention and preparation. Technology and educators must be sponsored and educated to be widely accepted and effective.

Advancements in IVR Technology

IVR technology has changed digital world interaction. Innovative entertainment and gaming have opened new doors in healthcare, education, and other disciplines. Comprehending these technical breakthroughs is key to comprehending immersive virtual reality's revolutionary impact. With lifelike and powerful hardware, IVR technology progresses. Modern VR headsets provide haptic feedback, high-resolution screens, and motion tracking to immerse users (Leeb & Pérez-Marcos, 2020). These innovations improve user experience by combining real and virtual worlds. VR equipment is lighter and more ergonomic, improving comfort and usability. Along with technology, VR software has helped create immersive virtual worlds. Complex components, dynamic simulations, and realistic virtual reality settings are created using advanced programming and graphics engines (Heinemann et al., 2023).

These developments allow for realistic training simulations and fantasy instructive domains. User immersion is enhanced by more responsive and high-quality VR software. IVR has also been enhanced with AI. AI algorithms make virtual worlds faster and more versatile. AI enables fast interactions, personalized content, and user behavior adaptation (Catala et al., 2022). This function enhances simulation accuracy and situational awareness in educational and training environments and customizes virtual reality. IVR also advances multimodal input. Networking has also made IVR more cooperative and accessible. High-capacity, low-delay networks enable immediate user-to-user communication in collaborative virtual environments (Yang & Yang, 2022). Cooperative learning, team training, and virtual social relationships alter substantially. VR enriches experiences and connects people across borders. Supports virtual community and collaboration. The increased cost and accessibility of IVR technologies signal democratization. VR solutions are getting cheaper and more accessible. As VR technology grows cheaper, education, healthcare, and business training may employ it. The democratization of IVR technology helps its diffusion into daily life.

Previous Studies on IVR in Education

Academic research has shown how IVR (Immersive Virtual Reality) technology affects student engagement, learning, and education. This research illuminates the merits and downsides of IVR in education, with most studies focusing on how IVR engages students. Dada et al., (2023) discovered that students are highly engaged and feel present in VR situations due to their interactive and immersive nature, which has been found to improve instruction in subjects such as physics, mathematics, history, and language studies. These results suggest that IVR may boost student motivation and engagement. Previous research has also examined how IVR influences academic achievement, revealing that virtual reality simulations enhance comprehension and retention of knowledge (Calvert & Abadia, 2020), particularly in helping students understand complicated scientific concepts. IVR technology may enhance educational interventions and learning outcomes across various subjects. It has been studied not

only for its impact on student engagement and academic performance but also for its role in fostering social cooperation (López-Fernández et al., 2021). Online peer sharing within VR environments boosts student engagement and communication, while collaborative VR experiences improve student communication, collaboration, and sense of community. Thus, VR enhances social learning and collaboration in educational settings.

Despite its benefits, the adoption of IVR in education faces several hurdles. Integration may be hindered by system vulnerabilities, hardware restrictions, and a lack of expertise (Li et al., 2023). Educational institutions often worry about the costs and logistics of VR adoption due to limited resources. To sustain IVR in education, these challenges must be addressed. The study also explored teachers' and students' views on IVR in the classroom, finding that while faculty and students generally appreciate the immersive nature of VR, their comfort levels and attitudes toward the technology vary. Effective integration of IVR in education requires understanding educators' viewpoints on its educational benefits, their competence in using the technology, and their willingness to incorporate it into their teaching practices (Tzima et al., 2020). This understanding is crucial for developing effective IVR support networks and professional development programs for educators.

3 Methodology

Participant

Chinese primary students in grades 4-6 participated in this qualitative study (Table 1). The purposive sample included students with different VR experiences. Participant selection criteria ensured a diverse age and educational perspective. Children in certain elementary school grades who utilized IVR for fire safety instruction exceeded inclusion guidelines. Using the technology directly enables participants to fully explore their ideas and experiences. Grades 4-6 were chosen because students this age have high cognitive development and may share educational experiences. For a diverse sample, we picked pupils from several elementary schools in the region. Different instructional environments, materials, and IVR experiences across schools were used. To gain diverse viewpoints on environmental factors' impacts. Exclusion criteria limited the study to elementary school students who took IVR fire safety classes. The research excluded students who had never experienced IVR or were not in a VR-based fire safety curriculum. This criterion enhanced the focused study of virtual reality's effects on fire safety education by ensuring participants had a similar understanding. Sampling continues until data saturation. When further interviews yielded no new information or themes, saturation suggested a comprehensive comprehension of participants' opinions. This technique secured a large sample size to include a diversity of experiences while balancing time and money. This research employed purposive sampling and inclusion/exclusion. To extensively study primary school students' thoughts on IVR for fire safety instruction. The rigorous selection criteria and ethical concerns prioritized collecting authentic and relevant remarks from participants in the designated age range and educational setting.

Table 1: Demographic Profile of Respondents

Participant ID	Grade	Age	Gender	VR Exposure (hours)
P001	4	9	Female	10
P002	5	10	Male	15
P003	6	11	Female	12
P004	4	9	Male	8
P005	5	10	Female	20
P006	6	11	Male	18
P007	4	9	Female	14
P008	5	10	Male	11
P009	6	11	Female	16
P010	4	9	Male	13
P011	5	10	Female	9
P012	6	11	Male	17
P013	4	9	Female	19
P014	5	10	Male	10
P015	6	11	Female	15
P016	4	9	Male	16
P017	5	10	Female	14
P018	6	11	Male	12
P019	4	9	Female	11
P020	5	10	Male	20
P021	6	11	Female	8
P022	4	9	Male	18
P023	5	10	Female	15
P024	6	11	Male	14
P025	4	9	Female	12

Data Collection

Comprehensive semi-structured interviews with Grades 4-6 Chinese primary school children were conducted for the study (Table 2). Using semi-structured interviews, participants shared their thoughts, concerns, and experiences using IVR in fire safety education. Individual interviews provide a peaceful environment for participants to convey their perspectives. Individual interviews began with a quick and straightforward introduction. This introduction defined the study's purpose, stressed confidentiality, and secured voluntary participation. Building deep relationships with participants encouraged open and honest responses. The interview guide followed the study's research subjects and theoretical framework. Open-ended questions asked respondents about their experiences with IVR in fire safety instruction. Inquiries were used to assess participants' VR simulation reactions and reported benefits, challenges, and perceptions. The 30-45-minute interviews allowed participants to expound on their perspectives. By asking further questions, each participant's experience was fully understood. The data-collecting technique continued until saturation. When more interviews yielded repeated material, saturation indicated a comprehensive exploration of participants' perspectives. This method ensured a thorough and rigorous data collection process, yielding a wide spectrum of participant perspectives.

Table 2: Interview Guidelines

Variable	Interview Questions
Perceptions of VR	1. Can you describe your overall experience with IVR in fire safety education?
	2. How do you feel when using VR to learn about fire safety?
	3. What aspects of VR, in the context of fire safety education, do you find most interesting or engaging?
	4. Are there any challenges or difficulties you have encountered while using VR for fire safety education?
	5. How has your perception of fire safety changed after using VR technology?
Engagement and Experiences	6. Can you share specific moments during the VR fire safety sessions that you found particularly engaging or memorable?
	7. How would you describe the level of immersion you experienced while using VR for fire safety education?
	8. In what ways do you think VR enhances or detracts from your learning experience compared to traditional methods?
	9. Have you noticed any differences in your attention or focus during VR-based fire safety lessons compared to traditional lessons?
	10. How do you think VR contributes to creating a more interactive and immersive learning environment for fire safety education?
Learning Outcomes	11. Can you recall specific fire safety information or procedures that you learned through VR?
	12. Do you feel that VR helps you remember fire safety information better than traditional methods?
	13. In your opinion, how effective is VR in teaching you about fire safety compared to other methods you have experienced?
	14. Have you applied any fire safety knowledge gained through VR in real-life situations?
Comparison with Tradition	15. How does learning about fire safety through VR compare to traditional methods like textbooks or lectures?
	16. Do you prefer using VR or traditional methods for learning about fire safety, and why?
	17. Are there any aspects of traditional fire safety education that you think VR cannot replicate or improve upon?
	18. Can you identify any strengths or weaknesses of VR in conveying fire safety information compared to traditional approaches?
Integration into Curriculum	19. How do you think VR technology could be better integrated into the curriculum for fire safety education?
	20. What support or resources do you think teachers would need to effectively integrate VR into fire safety lessons?
	21. Do you believe VR should be a regular part of fire safety education in primary schools? Why or why not?
Perceived Benefits/Challenges	22. From your perspective, what are the advantages of using VR for fire safety education?
	23. Can you identify any challenges or drawbacks associated with the use of VR in learning about fire safety?
	24. How do you think VR technology could be improved to enhance its effectiveness in fire safety education?
	25. Do you think VR should be used for other subjects or topics in education? Why or why not?

Data Analysis

Braun & Clarke's, 2006 three-step qualitative data analysis was used in the study. Researchers transcribed and engaged with audio recordings to learn the information (Table 3). Transcripts were widely reviewed and revisited to understand elementary school students' stories. Observations and assessments were documented to prepare for additional research. Line-by-line coding was used to select relevant transcripts in the next stage. The codes were created using deductive and inductive approaches to ensure a full data investigation by comparing them. Continuous advancement in the coding methodology created new themes and verified code correctness (Li et al., 2023). The first codes were then grouped into preliminary themes that captured the most important aspects of participants' input and experiences. Theme creation and upgrading followed. Prior themes were completely evaluated for coding linkage and theme classification. Iteratively validating and improving themes ensured correctness and consistency with participant tales. Continuous discussions helped researchers to examine issue links and minimize duplicates. Comparisons validated and improved concepts throughout the investigation. This required contrasting fresh data with existing themes to create a flexible analytical method. Scholars debate and examine results to verify and find alternate explanations for themes. The analysis's reliability and trustworthiness improved since the iterative approach included participants' deep and diverse perspectives in the final theme framework. Verifying members improved analysis reliability. Participants reviewed a summary to remark and confirm interpretations. The findings were more credible since this iterative process matched participant viewpoints. Data processing continued until saturation when more interviews revealed no new information or subjects. We carefully designed the theme structure to represent students' ideas on IVR in fire safety training. The theme analysis's careful and iterative approach increased research rigour and validity.

Table 3: Data Analysis Process

Stage	Description
Familiarization	Researchers immersed themselves in the data by transcribing audio recordings and repeatedly reading transcripts to gain a comprehensive understanding of participants' narratives and experiences.
Generating Codes	A line-by-line coding process was employed to identify meaningful segments within the transcripts, both deductively and inductively, ensuring a thorough exploration of the data.
Theme Identification	Initial codes were organized into preliminary themes, capturing the core aspects of participants' responses and experiences, and providing a foundation for subsequent analysis.
Theme Development	Preliminary themes were subjected to a comprehensive review, refinement, and organization into a coherent thematic framework, considering relationships between codes and overarching themes.
Theme Refinement	The thematic framework underwent iterative refinement, ensuring themes accurately represented the depth and diversity of participants' perceptions while addressing redundancies and overlaps.
Theme Validation	Ongoing discussions among researchers facilitated the validation of interpretations and consideration of alternative explanations for identified themes, enhancing the credibility of the analysis.
Finalization	The thematic framework was finalized, capturing the essence of participants' perspectives on immersive VR fire safety simulations and providing a robust foundation for interpreting the study findings.

4 Results

The study examines how students perceive, experience, and learn from IVR fire safety scenarios. Due to the participants' thorough testimonies, researchers were able to detect trends, tendencies, and challenges while utilizing VR technology. This section analyzes students' views on IVR fire safety simulations, their involvement and experiences, the learning process and retention of information, and a comparison to traditional fire safety instruction. This section carefully analyses various factors and successfully integrates insights to help us understand how IVR technology influences fire safety training.

Students' Perceptions of IVR Fire Safety Simulations

The study provides vital insights into kids' perspectives of VR fire safety exercises (Figure 2). Extensive interviews with participants revealed several critical topics about students' experiences, perspectives, and remarks about using VR technology in fire safety teaching. Students enjoyed IVR fire safety exercises' intrigue and captivating features. Participant P003 praised the unique usage of VR to improve fire safety. I appeared to be attending a fire drill. P015 praised the virtual reality firing drills' believability. "It heightened my level of attentiveness." The preceding comments underline how dynamic IVR simulations are, which engage students in learning. Students also enjoyed virtual reality fire safety scenarios. "I got extensive knowledge about the correct procedures to be taken in the event of a fire by actively participating in virtual reality exercises." (P007). Participant P018 said virtual reality helped them learn fire safety by letting them read, watch, and do practical tasks. These statements show how VR may teach fire safety by allowing students to engage in controlled and supervised fire drills. Virtual reality fire safety exercises were realistic, immersive, and educational; therefore, students liked them. P012 said, "The simulated fire drill seemed extremely genuine." The fire alarms were loud and heat was felt. P020 said, "During the virtual reality fire drill, I experienced the feeling of being physically present inside the building." These statements demonstrate how virtual reality technology can immerse and authentically teach fire safety issues to kids. Supporting their earlier study, (Chen et al., 2020) discovered that realistic and immersive simulations improve student engagement and learning. VR technology in experiential learning may improve students' knowledge and retention of complex subjects, according to (Fromm et al., 2021). Despite virtual reality fire safety exercises, students saw potential drawbacks. VR sessions often caused motion sickness or discomfort for several participants. Impaired focus. P022 complained about the bulky VR glasses causing headaches. These statements emphasize student comfort and well-being when using VR technology in education. Students are apprehensive about school virtual reality technology accessibility. "Due to the lack of VR equipment in some schools, not all individuals have the chance to partake in the experience," P016 said. Class member P024 remarked that limited glasses limit VR fire drills. These remarks underscore the need for equal VR access for all students to benefit from immersive learning. Mathur et al., (2023) say educational institutions must overcome technological barriers and provide equal VR access. Delamarre et al., (2021) stress the importance of teacher training and support to successfully integrate VR technology into the curriculum and overcome any challenges.

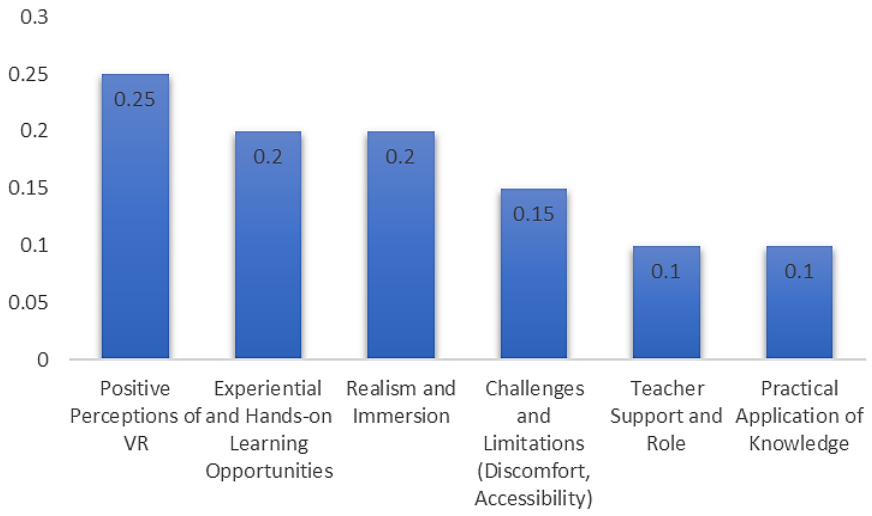

Figure 2: Students' Perceptions of Immersive Virtual Reality Fire Safety Simulations

Experiences and Engagement Levels

Research illustrates VR fire prevention simulation involvement and experiences (Figure 3). The interviews show how VR technology affects students' experiences. Many participants enjoyed virtual reality fire safety exercises, showing the digital world's attractiveness. It was like being in a video game in real life, said participant P004. "I found it extremely captivating!" P014 commented, "I was highly focused during the VR fire drill." "I experienced a sense of immersion in the events unfolding." These quotations demonstrate how VR simulations immerse and focus students, enhancing learning and leaving a lasting impression. Participants also stressed the value of VR's immersive, hands-on learning. P008 reported they could perform virtual reality tasks that were impossible during a fire drill. "It was significantly more pleasurable!" Participant P019 appreciated the chance to mimic fire emergencies for practical training without a fire. It felt like a major distraction. The preceding quotations demonstrate the usefulness of virtual reality in providing authentic and compelling environments for fire safety exercises and procedure reinforcement. Robertson, (2023) agrees that experiential learning improves student engagement and retention. Rossana et al., (2020) found that virtual simulations provide engaging learning environments. Student involvement improves across academic situations. It's important to remember that some people have bad experiences. Some pupils are worried about motion sickness and discomfort during virtual reality education. The VR glasses caused dizziness in P010. Concentration was tough with such great feeling. Like Participant P023, "I derived pleasure from the experience, although I occasionally experienced mild nausea after utilizing the virtual reality technology." "It is not suitable for all individuals." The remarks highlight a potential VR technological issue and underline the necessity of student physical health and welfare during immersive experiences. All participants highlighted the importance of a helpful learning environment in engaging people with VR fire safety simulations. "Before commencing the virtual reality experience, our instructor provided a comprehensive explanation", P001 said. This made it more comfortable to use. P013 also valued the instructor's responsiveness. Gained confidence. These phrases stress teacher support for a pleasant and engaging VR educational experience. Remacle et al., (2023) agree that instructor leadership and support are crucial to virtual reality technology's educational benefits. A suitable learning environment enhances student engagement in virtual reality educational interventions.

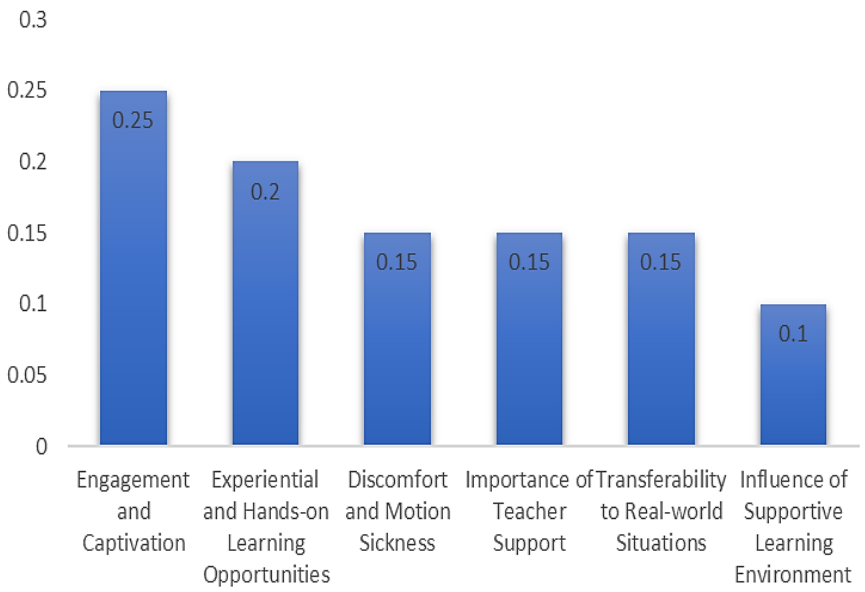

Figure 3: Student Perception of Experiences and Engagement Levels

Learning Effectiveness and Knowledge Retention

Students are being tested to determine if they can remember and learn from IVR fire prevention scenarios. Interviews show how VR influences students' learning and fire safety retention (Figure 4). Participants often commented how VR helps educate fire safety. VR helped participant P006 recall fire safety. "It's like I can see it in my head." Participant P017 claimed virtual reality helps them remember class topics better than reading or listening. These quotes show how VR may improve fire safety education by combining visual and experiential elements. Hamilton et al., (2021) discovered immersive experiences boost learning and memory. Rim & Shin (2022) add that VR simulations assist students in learning complicated concepts hands-on. Participants also described real-life applications of virtual reality fire safety simulations. Participant P009 said the virtual reality experience taught her how to handle a school fire drill. "I appeared to have previously rehearsed it." P019 said, "I shared the fire safety advice I gained in virtual reality with my family." "They thought it was cool." The pragmatic use of virtual reality information may have lasting effects on student behaviour and consciousness. However, several participants struggled to apply virtual reality simulation findings. P024 said, "The situation changes drastically in the event of a real fire." "While VR is beneficial, actual exercises remain the most important means of training." Participant P003 said, "While I do recall the VR drills, recalling every detail during a real emergency is challenging." These quotations show how VR may mimic real-life intricacy and urgency. Lowell & Tagare (2023) recommend integrating virtual and real-world practice to promote knowledge transfer. Brannon Barhorst et al., (2021) recommend mixing VR with hands-on activities to improve learning and retention. Active engagement in learning outcomes was also underlined by participants. The beautiful and practical action helped me concentrate, commented P012. This helped me recall fire safety. I loved VR learning, stated P021. I tried harder since I didn't want to study. These quotations show how virtual reality-based fire safety training links active participation, pleasure, and academic success.

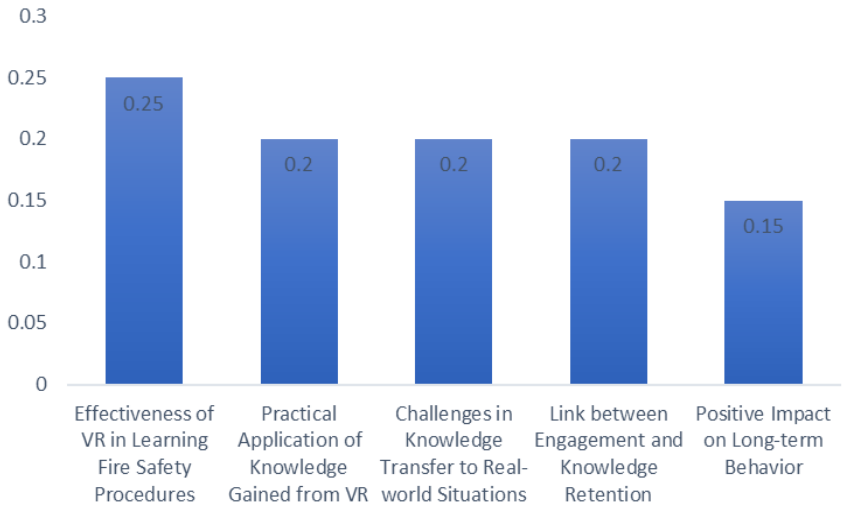

Figure 4: Student Perception of Learning Effectiveness and Knowledge Retention

Comparison with Traditional Fire Safety Education Methods

This study contrasts students' thoughts on IVR fire safety simulations with traditional fire safety training. Participant interviews record student perceptions of both methodologies' pros and cons. Virtual reality fire safety scenarios were preferred by participants. VR made Participant P005 feel like they were in another universe. It's more interesting than hearing the talk. P016: "The virtual reality fire drills are more exciting." "The experience is dissimilar to studying from a textbook." Participants found VR simulations more intriguing than traditional training. Hong et al., (2023) found VR technology improves student engagement and learning fire safety training. Babalola et al., (2023) found immersive simulations outperformed traditional techniques in various educational areas. Others preferred fire safety instruction over virtual reality (Figure 5). According to P011, all options are good, but regular reading and understanding are essential. P022 liked accurate literature in virtual reality. These remarks show a grasp of the benefits of conventional methods, highlighting the need for comprehensive education.

According to (Najmanová & Ronchi, 2023a), a holistic instructional strategy that mixes traditional methods with contemporary technologies improves learning results. Seddighi et al., (2023) also emphasize the need to use a variety of teaching approaches and accommodate different learning styles to meet students' needs. Participants also discussed each strategy's usability and availability. Participant P008 said books are always available, but VR goggles are not. Thus, literature is more accessible. P018 said virtual reality is fun but takes a long time to set up. "Books enhance and accelerate the efforts of educators." The above statements explain the logistical considerations that impact the practicality and viability of different teaching methods in an educational setting. Rahman et al., (2022) discovered that instructional technology applicability depends on logistical factors such as resource availability and cost. Nakum et al., (2022) say educational interventions must be realistic and straightforward to implement to succeed. Participants chose based on familiarity and comfort. P013 says "I derive enjoyment from my knowledge." Common novels seem cosy. Participant P024 says VR is weird. I prefer traditional learning. These remarks emphasize knowing and being comfortable with established methods, which may affect students' selections.

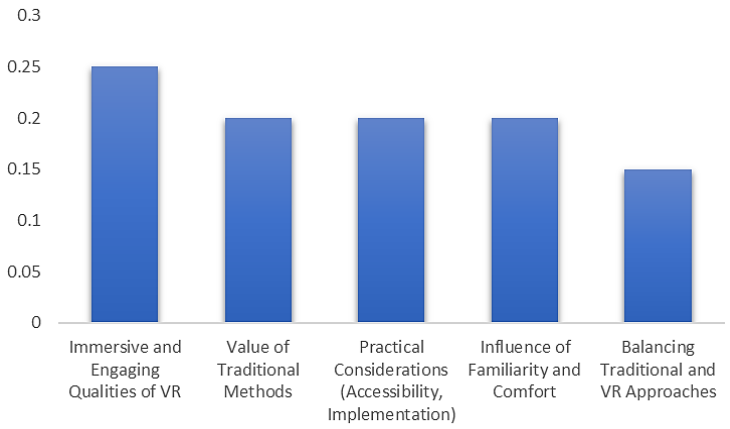

Figure 5: Comparison with Traditional Fire Safety Education Methods

5 Discussion

This article examines students' sophisticated VR fire safety simulation interactions. Prior academic research and current investigation qualitative data are used. These requirements demonstrate a thorough grasp of how IVR technology influences students' fire safety perceptions and experiences. Measurable findings mirror existing studies, demonstrating immersive and interactive VR technology may fascinate students. The weighted analysis stresses how positive viewpoints, hands-on learning, and pragmatism shape students' experiences. Grabowski, (2021) agrees with participants on VR fire drills' realism and "video game" quality. Experts say virtual simulations can make learning fun and intriguing.

The findings corroborate (Menzemer et al., 2023) by showing how virtual reality knowledge may be implemented. Participants recalled using virtual reality fire safety skills in real-life circumstances. Practicality illustrates how VR may enhance theory and lifesaving abilities. This breakthrough links theory with practice, which is essential to educational interventions. However, the research presents VR technological challenges including emotional discomfort and accessibility. Altan et al., (2022) emphasize overcoming technical challenges to acceptance, which aligns with literature warnings. Participants' worries about disorientation and classroom VR equipment challenges highlight the need for a comprehensive approach to incorporating VR technology into elementary school curricula. Analysis of student participation and experiences considers teacher aid and a learning-friendly atmosphere. Al-Ansi et al., (2023) say direction and help are necessary to maximize VR's educational advantages. Weightage analysis stresses teacher aid. Participants' appreciation of teacher explanations and help highlights educators' importance in virtual reality-based learning success. Traditional fire safety teaching has a subtle perspective. Participants' acknowledgement of conventional methods and preference for virtual reality's engaging and exciting features are consistent with academic literature that promotes holistic education and adds value to accessibility and implementation. Harknett et al., (2022) reveal that logistical factors are vital when incorporating VR technology into education to enhance efficiency. Numbers support scholarly debate about applying virtual reality skills. Participants' reports of how they used fire safety advice from VR simulations mirror, demonstrating that VR-enhanced immersive instruction may change students' behavior and awareness (Mao et al., 2024).

This shows that virtual reality can teach practical skills and impact real-world behavior and decision-making, which is crucial in fire safety education. However, the difficulties participants had applying VR simulation knowledge to real-life settings highlighted how VR technology can accurately simulate crisis

complexity and criticality. This research supports (Najmanová & Ronchi's, 2023b) call for a holistic strategy that combines virtual and physical exercise to promote knowledge transfer. To achieve complete and successful learning, the study stresses the need to thoroughly examine VR technology's restrictions and set additional requirements (**Table 4**). A stronger grasp of traditional fire safety training approaches is shown. Students liked virtual reality's excitement, but they still liked traditional techniques. Traditional schooling is appreciated with weightage analysis technology. User choices were impacted by convenience, familiarity, and availability. Tuma et al., (2021) recommended considering cost and resource availability when analyzing instructional technology's practicality. Kwegyir-Afful, (2022) revealed that familiarity influences students' ratings of instructional strategies, matching their knowledge of traditional approaches' familiarity and simplicity. The argument reveals how participants understand how a good learning environment influences learning and engagement. It's been shown that supportive environments boost student performance in VR-based educational interventions. Whether using VR or traditional means, instructors must create a suitable learning environment.

Table 4: Comparative Overview of Learning Approaches

Aspects	Immersive VR Fire Safety Simulations	Traditional Methods
Positive Engagement	High engagement due to experiential learning	Moderate engagement with traditional instructional methods
Practical Application of Knowledge	Strong application in real-life scenarios	Limited real-world application
Challenges in Knowledge Transfer	Some challenges due to differences from real-world scenarios	Generally aligned with real-world situations
Long-term Impact on Behavior	Positive impact on behavior and retention	Limited evidence of lasting impact
Importance of Teacher Support	Significant role in facilitating understanding	Important but may not be as immersive
Influence of Supportive Learning Environment	Positive impact on engagement and learning	Supportive but may lack the immersive quality
Accessibility and Ease of Implementation	Accessibility concerns due to equipment requirements	Generally accessible and easy to implement
Familiarity	Maybe less familiar, requiring adaptation	Familiar and well-established in educational settings

6 Conclusion

To conclude, students' involvement in IVR fire safety simulations suggests that VR can improve fire safety teaching. We explored how IVR simulations affect students' perceptions, experiences, and academic achievement. Studies found that IVR technology boosted student engagement and learning. Participants enjoyed realistic, interactive VR fire safety exercises. Fire safety exercises utilizing VR simulations taught students critical processes and safety criteria. The quantifiable data demonstrated that virtual reality simulations boosted student performance. This proves VR fire safety education works. The study also contrasted IVR simulations with fire safety instruction, highlighting its merits and downsides. VR simulations were praised for their immersive learning and user involvement, while

traditional methods were preferred for their familiarity and ease of use. This study stresses the significance of fair teaching that combines current and old approaches to optimize educational gains. The study explored the merits and cons of IVR in classes. Implementation challenges include teacher training, accessible equipment, and technology. This study illustrates the importance of professional development and infrastructure for academic VR implementation. The study also underlined the importance of teacher leadership for IVR technology's educational benefits. Teachers prepared, supported, and promoted self-reflection on virtual reality fire safety scenarios. Student VR confidence and involvement increased in a supportive learning environment. Teachers need constant training to use VR in the classroom.

7 Implications

Theoretical Implications

The study's theoretical implications advance fire safety education using IVR in primary schools. Students' favorable experiences with VR fire safety simulations contribute to the educational uses of immersive technology conversation. The empirical data support the theory that IVR boosts student engagement, experiential learning, and information retention. This study supports theoretical frameworks that emphasize interactive and immersive teaching experiences. The emphasis on teacher aid and contrast with traditional ways support a harmonic strategy that combines technology developments and long-standing educational practices. This study shows that IVR technology can transform fire safety training. This establishes the basis for educational technology research and conceptual frameworks.

Practical Implications

This research can assist lawmakers, educators, and curriculum developers improve elementary school fire safety. IVR fire safety scenarios are being tested for teaching value. VR technology can help teachers create engaging fire safety learning environments for students. The findings emphasize the relevance of equipment availability and instructor skills when adopting virtual reality-based educational interventions. Practical issues need educators to undertake continual professional development to successfully integrate VR technology into their instruction. Studying the advantages and downsides of VR and traditional techniques lets educators be objective and tailor their lessons to students' learning preferences. The study also stresses the importance of fair VR resource allocation for immersive learning for all students. This would eliminate educational gaps. Policymakers should investigate how to integrate VR into curricula. Support system development and resource allocation are needed to smoothly implement immersive instructional technology. Due to practicality, educational technology companies provide VR systems that are easy to use. Technology must enhance the user experience to make virtual reality more accessible and acceptable for younger children due to anxiety and motion sickness. Research may help universities innovate by overcoming obstacles and leveraging IVR technologies. The findings affect elementary school reformers. It gives insights that can improve fire safety training approaches.

8 Limitations

Despite its important findings, this study has certain drawbacks. The study first focused on Chinese elementary school students in grades 4-6. Students of different ages, educational levels, and cultures

may not find the findings immediately relevant. Instructional styles, cultural perspectives, and technological skills might affect results. Future studies should include more diverse persons to boost external validity. The research also relied extensively on student self-reports. This strategy produced valuable qualitative data, but participants' stories may have been biased and subjective. Students may be influenced by socially acceptable comments or misremember their experiences. Instructor feedback and observational metrics may help explain how virtual reality technology affects fire safety instruction. The scope and duration of the study may have affected the findings. VR immersion was a brief break in the main program. Longer intervention length may promote participation in virtual reality fire safety simulations and comprehension of long-term effects. It is important to note that the research only provided fire safety advice. Thus, the findings may not apply to different educational environments. IVR technology may improve learning in various areas and aims. More research is needed. The study also ignored social and cultural factors that may affect students' access to IVR technology. Cultural views about instructional technology, technical access, and socioeconomic position may affect the findings' generalizability. Future research should consider these contextual factors to better understand IVR and educational outcomes. The study did not examine how IVR technology affects students differently based on their technical experiences or learning styles. Understanding how these aspects affect IVR education may help educational specialists concentrate.

9 Future Directions

This analysis suggests various research fields. To increase generalizability, participants should come from a variety of educational systems, age ranges, and ethnicities. Comparative studies on different groups can show how IVR technologies work and are accepted in education. Future research should include teacher comments, observational measures, and self-reported data. This strategy permits data triangulation and a deeper understanding of how VR technology influences student engagement, learning outcomes, and education. The long-term consequences of IVR therapy on information retention and behavior must also be studied. Learning how well students remember fire safety may indicate the long-term advantages of IVR experiences. Future studies may investigate how IVR technology may be used in other academic subjects. We can understand its academic uses by testing its efficacy in physics, arithmetic, and language learning. Future research should comprehensively investigate socioeconomic and cultural aspects impacting VR accessibility and utilization. Understanding how contextual factors impact IVR treatment efficacy may help us understand educational policies and practices. Analyzing student technology use and learning habits may explain IVR therapy. Different student groups can benefit from customized approaches.

10 Conflict of Interest

No potential conflict of interest was reported by the authors.

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