Applying Virtual Reality (VR) Technology to Improve Emergency Rescue Skills program: A Case Study of Sichuan province

Gang Xin

A Thesis Submitted in Partial Fulfillment of Requirements for
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ABSTRACT

This study investigates the application of Virtual Reality (VR) technology in enhancing emergency rescue training, using the Sichuan Disaster Prevention and Reduction Museum in Chengdu, China, as a case study. Against the backdrop of increasing natural disasters and public safety concerns, the research addresses the limitations of traditional training methods and evaluates the effectiveness of VR-based instruction in improving public emergency preparedness. Employing a quasi-experimental design with both quantitative and qualitative methods, the study compares two groups: a VR-trained experimental group and a traditionally taught control group. The research sample comprised 471 participants who engaged in either VR simulations of fire emergencies or conventional classroom sessions. Key variables assessed included knowledge acquisition, response speed, skill performance, and user satisfaction. The findings reveal that VR training significantly enhances learners' comprehension, practical skills, and emotional preparedness, offering immersive, interactive, and authentic emergency scenarios. Notably, participants in the VR group demonstrated faster learning, higher satisfaction, and greater confidence in disaster response. Moreover, they perceived VR to be more engaging and conducive to personalized learning compared to traditional methods. Statistical analyses, including chi-square tests and correlation analysis via SPSS, confirmed significant differences between the two groups, with VR training yielding superior outcomes in most areas. However, areas for improvement in VR design were identified, including equipment comfort, visual clarity, and motion sickness issues. This study underscores the transformative potential of VR in emergency education, advocating for its broader adoption in public safety training. It contributes valuable insights into the development of immersive educational models, supporting a shift toward more dynamic, accessible, and effective disaster preparedness strategies. The findings have practical implications for policy makers, educators, and emergency planners aiming to enhance societal resilience through technology-driven solutions.

Keyword : Virtual Reality, Emergency Rescue Training, Disaster Preparedness

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CHAPTER I
INTRODUCTION

1.1 Research background

The movement of the Earth engenders four primary cycles (Handy & Brun, 2004; Holtslag et al., 2013; Oki et al., 1999; Rispoli, 2023), which precipitate natural calamities (Lorini et al., 2020) such as earthquakes, floods, and typhoons, relentlessly imperiling human survival. Confronted with these natural disasters, the fate of humanity intertwines, sharing a common destiny. Within this community of shared futures, collaborative efforts are imperative to confront the challenges of natural disasters and to construct a safer and more sustainable future. Nevertheless, public awareness of disaster prevention and mitigation remains deficient in certain regions, attributed to a lack of understanding of disaster risks and inadequate systematic training. Consequently, this results in relatively limited self-protection and self-help capabilities during disasters, and a lack of societal engagement in the disaster prevention and relief efforts (Chana, 2022)

In recent years, the Chinese government has endeavored to enhance public awareness of disasters and disaster prevention through various channels (Chana, 2022). However, to significantly augment regional disaster prevention and mitigation capacities and to bolster the self-help and mutual aid skills of the populace, further incentives are necessary to encourage public participation. Against the backdrop of rapid technological advancement, novel technologies present substantial opportunities and advantages for disaster prevention and mitigation training. Advanced technologies such as Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence (AI) have demonstrated considerable potential in the educational domain. Against the backdrop of these technologies, an immersive and interactive training environment is established, enabling the precise replication of disaster scenarios in virtual settings. Consequently, trainees can immerse themselves in these simulations, gaining deeper insights into the perils and challenges created by disasters. For instance, VR technology is excellent in simulating various disaster scenarios, including earthquakes, floods, and fires, facilitating trainees in acquiring skills in correct evacuation procedures, self-rescue techniques, and mutual assistance strategies, thereby enhancing their preparedness for real-world disasters. Virtual reality is a technology growing exponentially, having found widespread application in the healthcare sector in recent years, serving as an effective tool when managing various ailments (You et al., 2005). VR technologies allow trainees the opportunity to engage in learning within the confines of their personal spaces. For instance, workers acquire higher proficiency in equipment usage or adherence to safety protocols through VR simulations conducted at home. Depending on the context, VR training offers privacy to trainees, particularly in instances where individuals may feel apprehensive under the watchful eyes of observers during conventional training sessions. Nonetheless, some of the training scenarios necessitate the presence of instructors to provide prompt feedback on trainee performance and to address any issues or negative trends in performance (Xue et al., 2020).

Augmented reality (AR) technology seamlessly integrates training content with real-world environments, thus rendering training experiences lifelike and augmenting participants’ engagement and efficacy. Simultaneously, artificial intelligence (AI) technology adjusts training content, and difficulty levels based on trainee feedback and performance, thus it facilitates personalized and targeted training outcomes. We adopt emerging technologies to enhance training effectiveness and elevate training appeal and participation as well. In comparison with traditional paper-based materials or classroom instruction, the immersive and interactive experiences offered by these technologies are more apt to capture public interest and foster enthusiasm for participants. Moreover, the audio-visual effects and real-time feedback from these technologies render training sessions more vivid and engaging, thereby enhancing participants' learning experiences and retention rates.

Consequently, the combined application of these new technologies not only serves to heighten public awareness and understanding of disaster prevention and mitigation but also enables the rapid expansion of regional disaster preparedness capacities and the enhancement of self-help and mutual aid skills among the populace. This chapter delves into the profound role of new technologies in disaster prevention and mitigation training, illustrating the imperative need to bolster public willingness to engage while underscoring the innovative and forward-thinking nature of the endeavor. Moreover, the advancement of disaster prevention and mitigation technologies should transcend national, racial, religious, and ideological boundaries, striving for more universal and efficacious technical solutions.

In this vein, exemplifying post-disaster reconstruction efforts following the "May 12 Wenchuan Earthquake," the Sichuan Disaster Prevention and Reduction Museum, located in Chengdu, endeavors to leverage modern high-tech means to promote and disseminate disaster prevention and mitigation skills. The Sichuan Disaster Prevention and Reduction Museum primarily employs multimedia displays complemented by the audio-visual and electronic elements, with interactive experiences serving as the focal point. Through immersive sensory experiences encompassing visual, auditory, and tactile stimuli, visitors gain profound insights into disaster scenarios, acquire self-help and mutual aid skills, and enhance safety awareness.

In recent years, to enhance public awareness of disaster prevention and mitigation and to optimize training outcomes, the museum established a dedicated VR fire experience area, leveraging virtual reality technology. This initiative provides visitors with immersive experiences, enabling them to grasp the dangers and urgency of fire incidents in a controlled setting and to learn correct evacuation and self-help procedures. Through these immersive encounters, visitors develop a deeper understanding of the perils posed by fires and augment their disaster response capabilities. This innovative approach to disaster prevention and mitigation training not only enhances public engagement and learning outcomes but also furnishes a vital platform for disaster education across all sectors of society.

The study used samples from the Sichuan Disaster Prevention and Reduction Museum, which was chosen because it has good sampling practices and accurate data. This allowed for thorough research to be done, and the study also pushed for the standardization, mass distribution, and socialization of disaster prevention and mitigation education, which helped the global effort to prevent and reduce disasters. With the rapid advancement of science and technology, virtual reality (VR) technology has emerged as a prominent frontier, offering unparalleled value and potential. With its immersive experiences, VR technology transports individuals to alternate realities, facilitating deep and intuitive comprehension and experiences within virtual environments. This technology is revolutionizing disaster response capabilities and rescue operations in China, particularly within the ambit of the Sichuan Disaster Prevention and Reduction Museum. The Sichuan Disaster Prevention and Reduction Museum endeavors to enhance public awareness and proficiency in disaster prevention and response. Leveraging virtual reality (VR) technology, the museum offers visitors highly realistic simulations of disaster scenarios, enabling them to safely experience various crises such as earthquakes, floods, and fires. By immersing themselves in these simulations, visitors develop their emergency response capabilities for disasters. Specifically, VR technology enables visitors to practice using fire extinguishers and executing escape plans in fire scenarios, thereby refining their fire response skills and acquiring correct self-help and mutual rescue techniques. The immersive simulation experience deepens the visitors' understanding of the disaster risks and response strategies and enhances their responsiveness and survival skills in real world disasters. In essence, virtual reality technology not only introduces a novel and effective approach to disaster education for the public but also offers convenience and support for the rescue personnel's training and practical exercises. This innovative fusion of technology and education, safety, and emergency response heralds a revolutionary transformation in the realm of disaster prevention and rescue, thereby making a significant contribution to societal safety and stability.

With the escalating frequency of natural disasters and emergencies, the public's capacity for emergency response has garnered significant societal scrutiny. The advent of virtual reality (VR) technology offers a novel concept and potential solution to address this pressing challenge. Integrating VR technology into disaster prevention and mitigation education centers enables the simulation of diverse disaster scenarios, allowing visitors to experience and acquire correct methods and skills for managing disasters. This immersive learning approach enhances the public's emergency response capabilities and fosters a heightened awareness of self-help and mutual assistance, thereby enabling more effective protection of oneself and others during disasters.

The imperative to enhance rescue skills in China and other nations underscores the importance of disaster prevention and mitigation education. However, traditional educational methodologies are often constrained by factors such as location, equipment availability, and safety considerations, thus failing to provide the public with authentic and immersive disaster response experiences. Introducing VR technology presents a viable solution to this challenge, offering a novel simulation platform for public rescue training. Through VR-based simulation exercises, learners repeatedly practice in realistic disaster scenarios, acquaint themselves with diverse rescue procedures and response strategies, and enhance the precision and efficiency of their emergency responses. VR technology enables trainees to engage with disaster scenarios within a secure environment, enabling them to learn and master correct evacuation techniques. Amidst the rapid advancement of VR technology, its broad application across various domains has attracted widespread attention. This study not only explores the utilization of cutting-edge technology but also directly contributes to the enhancement of overall societal security levels, holding paramount strategic significance.

1.2 Research Aims and Objectives

1.2.1 Research aim

This study aims to evaluate the effectiveness and impact of Virtual Reality (VR) technology in enhancing emergency rescue training outcomes for the general public, using the Sichuan Disaster Prevention and Reduction Museum as a case study. The research seeks to explore how immersive simulation-based training can improve disaster awareness, response capabilities, and learner engagement when compared to traditional training methods.

1.2.2 Research Objectives

1) To analyze the practical application and integration of VR technology in disaster preparedness education at the Sichuan Disaster Prevention and Reduction Museum.

2) To assess the effectiveness of VR-based emergency rescue training in enhancing knowledge retention, response speed, and decision-making among participants, as compared to conventional offline methods.

3) To examine changes in participants' behaviors, attitudes, and self-efficacy regarding disaster awareness following VR-based training experiences.

4) To explore the perceived usability, acceptability, and limitations of VR emergency training systems from the perspective of diverse user groups.

5) To identify key factors (technological, cognitive, experiential) influencing the learning outcomes and satisfaction levels of VR-based training participants.

1.3 Research Questions

This study aims to explore in depth the application of VR technology as a new educational tool, and the advantages of VR technology to simulate real scenarios to provide new possibilities for emergency rescue training.

1) How effective is Virtual Reality (VR) technology in enhancing emergency rescue skills and disaster preparedness compared to traditional training methods?

2) What impact does VR training have on learners' knowledge, attitudes, and confidence in emergency response situations?

3) What are the challenges and opportunities in implementing VR-based training for disaster preparedness education?

1.4 Significance of the study

Through this study, we aim to provide theoretical support and practical guidance to apply virtual reality technology in disaster prevention and reduction education. With new technology, we hope to promote continuous improvement of human disaster prevention and reduction capacity; and make greater contributions to protecting people's lives and property. The significance of this study lies in exploring the application of virtual reality technology in disaster prevention and reduction education and constructing a social emergency response system to provide scientific support and technical guidance.

CHAPTER II
LITERATURE REVIEW

With the rapid development of VR technology, its application across various fields has garnered significant attention. This study aims to explore the application of VR technology in the Sichuan Disaster Prevention and Reduction Museum to enhance public emergency rescue skills. Research in this area not only encompasses the application of advanced technology but also the development of a social emergency response system. This is of considerable importance for improving the overall level of social security.

2.1 Overview of virtual reality technology

In recent years, Virtual Reality technology, a multi-disciplinary application that integrates computer graphics, human-computer interaction, and sensor technology, has made remarkable progress in various fields. Merriam-Webster's New General Complete Dictionary (Webster, 1988) defines virtuality as "essentially an effect that exists but does not actually exist" and reality as "the state or quality of reality", referring to things that exist independently of associated ideas, constituting real or actual entities, and distinguished from mere appearances. In the context of the book, virtual reality is defined as a computer-generated digital environment that can be experienced and interacted with similarly to a real environment (Ardiny & Khanmirza, 2018). By simulating virtual environments, VR technology enables users to perceive and interact in an immersive manner, offering new possibilities for emergency rescue training. According to research conducted by Ma Ying, Xie Yushi, Zhao Yiran, Li Jialin, and others, the characteristics of VR can be summarized into five aspects: a sense of existence, sense of autonomy, immersion, interactivity, and imagination, collectively referred to as "two senses and three characteristics", which possess universal practicability (Ma Ying, 2020).

Studies by Xu Jianxi, Zhao Tang, Yuan Xiaolin, Nie Yinyu, Wei Xihui, Zhang Jianjie, et al., describe the successful reconstruction of real railway accident scenes through a visualization framework based on the PhysX engine, facilitating effective virtual training where crane operators can safely experience real accident scenes (Xu et al., 2018). Similarly, research conducted by Tuva Fjærtoft Lønne, Havard R. Karlsen, Eva Langvik, Ingvild Saksvik-Lehouillier, et al., from the Department of Psychology at the University of Norway, indicated that the immersion of virtual reality technology in educational settings significantly influences the users' sense of presence and emotional response, potentially enhancing educational outcomes. This offers valuable insights and support for the application of virtual reality in education (Lønne et al., 2023). Virtual platforms are frequently utilized to simulate classrooms or laboratories, providing a safe environment for testing scenarios that would be impractical or hazardous to conduct in real life. Hence, the application of VR technology represents one of the developmental trends in disaster education.

2.2 The application of virtual reality technology in the field of education

Virtual reality (VR) technology, as a multidisciplinary application integrating computer graphics, human-computer interaction, and sensor technology, has made remarkable progress in various fields in recent years. Merriam-Webster's New General Complete Dictionary (Webster, 1988) defines "virtuality" as "essentially an effect that exists but does not actually exist" and "reality" as "the state or quality of reality," referring to things that exist, independent of associated ideas, constituting real or actual entities, and distinguished from mere appearances. In this context, Virtual Reality is defined as a computer-generated digital environment that can be experienced and interacted with, similar to a real environment (Ardiny & Khanmirza, 2018).

By simulating virtual environments, VR technology enables users to perceive and interact in an immersive manner, offering new opportunities for emergency rescue training. According to research conducted by Duan, Y. Y. et al. the characteristics of VR can be summarized into five aspects: sense of presence, sense of autonomy, immersion, interactivity, and imagination. These are collectively referred to as "two senses and three characteristics" and possess universal applicability (Duan et al., 2019).

Studies by Xu Jianxi, Zhao Tang, Yuan Xiaolin, Nie Yinyu, Wei Xihui, Zhang Jianjie, and others describe the successful reconstruction of real railway accident scenes through a visualization framework based on the PhysX engine. The framework facilitates effective virtual training and allows crane operators to experience real accident scenarios (Xu et al., 2018). Similarly, research conducted by Tuva Fjærtoft Lønne, Havard R. Karlsen, Eva Langvik, and Ingvild Saksvik-Lehouillier from the Department of Psychology at the University of Norway indicates that the immersion provided by VR technology in educational settings significantly influences users' sense of presence and emotional response, potentially enhancing educational outcomes. This offers valuable insights and support for the application of VR in education (Lønne et al., 2023).

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2.3 Virtual reality technology in emergency rescue training

Research on the application of Virtual Reality technology in emergency rescue training is still in its nascent stages, but there have been notable explorations in this field. Hong Kang, Jinseong Yang, Beom-Seok Ko, and colleagues investigated the utilization of VR technology in fire escape training (Hong et al., 2023). By seamlessly integrating Augmented Reality (AR) and VR technologies into a head-mounted display device, they developed a realistic, safe, and diverse fire drill training system. Their findings indicated that such an integration enhances the effectiveness of training and improves participants' emergency response abilities, particularly in comparison to those traditional methods. It underscores the advantages of combining AR and VR technologies, particularly in addressing the limitations of conventional fire drill training, thereby presenting a novel solution to enhance existing training methodologies.

Furthermore, Shujuan Liao, Moping Tan, Meichan Chong, and others proposed the inclusion of virtual reality teams in disaster response nursing courses to enhance the disaster preparedness, confidence, and performance of nursing students (Shujuan et al., 2022). This cost-effective simulation bridges the gap between insufficient disaster training and the importance of preparedness. Similarly, Chen Shiye, Lai Yingxun, Lin Yushan, and colleagues combined VR and computational thinking to develop an earthquake-disaster relief training system, aiming to cultivate students' practical knowledge and creativity (Chen et al., 2020). Jonathan R. Abbas, Michael M.H. Chu, Ceyon Jeyarajah, and others demonstrated that, despite variations in study design and quality, the use of VR in simulation-based emergency skills training yields educational benefits, including knowledge acquisition, simulation skills performance, acceptability, usability, and effectiveness (Abbas, Chu, et al., 2023). Similar studies have also reported success in earthquakes, floods, and other disaster scenarios. In her research on the popularization strategy of emergency rescue knowledge and the construction of training systems, Zhang Xiuting proposed leveraging Internet resources to enhance the effectiveness of traditional classroom training. Zhang suggested conducting online and offline interactive teaching activities, using the Internet and other cutting-edge technologies to achieve multidimensional communication and coordination between online and offline platforms (T., 2020).

2.4 Urgent public need for emergency literacy

The overarching objective of the Sendai Disaster Reduction Plan is to significantly reduce the global disaster mortality rate by 2030. The plan, as outlined by the United Nations in 2015, delineates ten key components to address requirements for disaster risk knowledge education, promotion methods, and scientific and technological cooperation. It aims to bolster overall disaster response capacity through widespread dissemination of emergency knowledge, fostering active participation from relevant stakeholders. This underscores the paramount importance placed by the international community in promoting emergency knowledge. The significance of disaster risk reduction education was underscored in the evaluation of progress on the Yokohama Strategy within the Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters, as articulated by the United Nations in 2005.

The Red Cross Society of China, serving as a primary advocate for the dissemination of mass emergency rescue knowledge in the country, highlighted in the Guiding Opinions on Further Promoting Red Cross Emergency Rescue Work that improvements have been made in the popularization of emergency rescue knowledge and skills. By 2022, the goal is for the number of individuals in China holding ambulance worker certificates to constitute no less than 1% of the total population, and this figure is projected to increase to no less than 3% by 2030 (Assembly, 2005). According to data from the Seventh Population Census of China, its total population reached 1,434,97,378 by 2020 (Chana, 2022).

Consequently, the Chinese Red Cross system is tasked with the training of approximately 28.86 million first responders between 2022 and 2030, without factoring in other training systems such as those for emergency and health personnel. Therefore, there is an urgent need for scientifically advanced training methods to support this substantial training demand.

2.5 Research gaps and deficiencies

The current research on VR emergency training exhibits several notable shortcomings, as identified through the examination of 20 references (Abbas, Chu, et al., 2023; Amico et al., 2023; Aoki et al., 2008; Bernardes et al., 2015; Chang et al., 2022; Chen et al., 2021; Duan et al., 2019; Feng et al., 2020; Hong et al., 2023; Hubail et al., 2022; Kočkár et al., 2023; Lønne et al., 2023; Samadbeik et al., 2018; Shujuan et al., 2022; T., 2020; Xue et al., 2020; Yu, 2022; Zhu & Li, 2021). Primarily, most studies focus on specific industries such as nursing, firefighting, and construction, with relatively few investigations on broader disaster prevention and reducing science popularization venues, such as disaster prevention and education centers. Secondly, there is a noticeable lack of in-depth discussion regarding the undeniable effectiveness and social impact of VR technology in specific emergency scenarios. Thirdly, no research has been conducted on the transmission speed of identical knowledge points between VR and traditional online and offline educational methods.

As a key institution for disseminating disaster prevention and reduction knowledge, the Sichuan Disaster Prevention and Reduction Education Center holds a unique advantage for addressing these research gaps. With an assessment of the existing facilities within the museum, researchers can gain deeper insights into how to integrate VR technology to enhance the efficacy and appeal of mass disaster reduction knowledge dissemination. This approach offers valuable contributions to the field by advancing our understanding of the optimal utilization of VR technology in emergency training and education.

2.6 Research relations

Almukhlifi et al. (2021) Studied of the emergency healthcare workers' preparedness for disaster management: an integrative review they implied that around 2 billion people globally were affected by natural disasters between 2008 to2018. The World Health Organization requires countries and governments to have disaster plans and emergency health workers ready and prepared at all times. To conduct an integrative review of literature of emergency healthcare workers' perceived preparedness for disaster management. An integrative literature review using the PRISMA checklist guidelines was conducted to explore physicians, nurses, emergency medical services and allied medical professionals' preparedness for disasters. Literature was searched from 2005, published in the English language and from MEDLINE (PubMed), Google Scholar, EMBASE, PsycINFO, SCOPUS, ProQuest and CINAHL databases. Reviews, case reports, clinical audits, editorials and short communications were excluded. Studies were critically appraised using the Mixed Methods Appraisal Tool. The results found that the initial search yielded 9589 articles. Twenty-seven articles were included following application of the eligibility criteria. Included studies were geographically diverse including North America, the Middle East and the Asia Pacific. Most studies (n = 24) assessed the knowledge of healthcare workers in general disasters. Studies using the Disaster Preparedness Evaluation Tool reported moderate disaster preparedness and knowledge, while studies using other instruments largely reported inadequate disaster preparedness and knowledge. Regional variations were recorded, with high-income countries' reporting a higher perceived preparedness for disasters than low-income countries. The majority of the emergency healthcare workers appear to have inadequate disaster preparedness. Previous disaster experience and training improved disaster preparedness. Future research should focus on interventions to improve emergency healthcare workers preparedness for disasters.

Khanal et al. (2022) Indicated that the study presents a systematic review of the literature on virtual reality (VR), augmented reality (AR) and Mixed Reality (MR) used in disaster management. They considered the factors such as publication type, publication year, application domain, and technology used. We surveyed papers from 2009 to 2019 available in the Web of Science and Google Scholar database, and 84 research articles were selected for the review study. After an extensive review of the literature, it was found that the XR technology is applied extensively in computer simulation modeling, interaction techniques, training, infrastructure assessment and reconnaissance, and public awareness areas of disaster management. They found diverse advantages, opportunities, and challenges of XR usage for disaster management, which are discussed in detail. Furthermore, current research gaps in the field of XR technology for disaster management technology, which are needed to better support disaster management, are identified and discussed in an effort to provide direction to the future research.

Bhugaonkar et al. (2022) There is no escaping Internet's favorite buzzword for 2022: The Metaverse. Everyone is talking about it, but only a few know what it is or how it works. One can look at the Met averse as a 3D model of the Internet where it is possible to spend your reality parallel to the virtual world. In broad terms, Metaverse can be explained as a virtual space, graphically rich, leaning towards verisimilitude where people can do all sorts of things they do in real-life such as shop, play, socialize, and party. The pandemic has accelerated innovations in the digital age. Looking beyond revolutions in telehealth, payments, remote monitoring, and secure data sharing are other essential innovations in the fields of artificial intelligence (AI), virtual reality (VR), augmented reality (AR), and block chain technology. The Metaverse is still in its nascent stage and evolving continuously, having a huge potential in health care to combine the technologies of AI, AR/VR, web 3.0, Internet of medical devices, and quantum computing, along with robotics to give a new direction to healthcare systems. From improving surgical precision to therapeutic usage and more, the Metaverse can bring significant changes to the industry.

Kouijzer et al. (2023) Indicated that virtual reality (VR) is increasingly used in healthcare settings as recent technological advancements create possibilities for diagnosis and treatment. VR is a technology that uses a headset to simulate a reality in which the user is immersed in a virtual environment, creating the impression that the user is physically present in this virtual space. Despite the potential added value of virtual reality technology in healthcare, its uptake in clinical practice is still in its infancy and challenges arise in the implementation of VR. Effective implementation could improve the adoption, uptake, and impact of VR. However, these implementation procedures still seem to be understudied in practice. This scoping review aimed to examine the current state of affairs in the implementation of VR technology in healthcare settings and to provide an overview of factors related to the implementation of VR. To give an overview of relevant literature, a scoping review was undertaken of articles published up until February 2022, guided by the methodological framework of Arksey and O'Malley (2005). The databases Scopus, PsycINFO, and Web of Science were systematically searched to identify records that highlighted the current state of affairs regarding the implementation of VR in healthcare settings. Information about each study was extracted using a structured data extraction form. The results shown that of the 5523 records identified, 29 were included in this study. Most studies focused on barriers and facilitators to implementation, highlighting similar factors related to the behavior of adopters of VR and the practical resources the organization should arrange for. However, few studies focus on systematic implementation and on using a theoretical framework to guide implementation. Despite the recommendation of using a structured, multi-level implementation intervention to support the needs of all involved stakeholders, there was no link between the identified barriers and facilitators, and specific implementation objectives or suitable strategies to overcome these barriers in the included articles. To take the implementation of VR in healthcare to the next level, it is important to ensure that implementation is not studied in separate studies focusing on one element, e.g., healthcare provider-related barriers, as is common in current literature. Based on the results of this study, we recommend that the implementation of VR entails the entire process, from identifying barriers to developing and employing a coherent, multi-level implementation intervention with suitable strategies. This implementation process could be supported by implementation frameworks and ideally focus on behavior change of stakeholders such as healthcare providers, patients, and managers. This in turn might result in increased uptake and use of VR technologies that are of added value for healthcare practice.

Abbas, O'Connor, et al. (2023) Implied that there has been significant advancement in virtual reality (VR) technology since its conception in 1960, and this evolution has particularly accelerated in recent years. Alongside this, we are seeing an expansion of research interest within which the definitions and nomenclature can be complex and lead to potential misunderstanding or confusion. We present a systematic review of definitions of the term VR as reported within the medical literature with the aim to establish the terminology used to define VR, the differences that exist through the literature, and if they have changed over time. By reporting according to the PRISMA guidelines, we present a systematic review of VR definitions in the English language medical literature. The databases Medline, PubMed, Web of Science, and Scopus were searched using the search terms “virtual reality”, “definition”, “defined”, or “define”. Articles were included if they were peer-reviewed, within the medical literature, published between 22nd December 2001 and 22nd December 2021, and offered either an original or cited definition for the term VR. Following data extraction, quantitative analysis of terminology over time and term density maps have been created. The results emerged that Eighty-eight studies were included offering 105 definitions of the term VR. Of these articles, 58 were published within the last 5 years. Common terms when defining VR included “computer”, “environment”, “user”, “interactive” and “simulation”. In recent years, a novel term “head mounted display” has emerged which was not previously featured in healthcare literature. This systematic review highlights that the published literature in the field of VR is rapidly expanding. With the growth in technology we can see a complex network of terminology emerge with little homogeneity. Definitions of VR are numerable and high variability exists. We recommend the requirement for consensus in order to urgently unify terminology within the immersive technology field, and whilst waiting for agreement, an evidence-based definition for VR has been suggested.

Halbig et al. (2022) Found that in recent years, the applications and accessibility of Virtual Reality (VR) for the healthcare sector have continued to grow. However, so far, most VR applications are only relevant in research settings. Information about what healthcare professionals would need to independently integrate VR applications into their daily working routines is missing. The actual needs and concerns of the people who work in the healthcare sector are often disregarded in the development of VR applications, even though they are the ones who are supposed to use them in practice. By means of this study, we systematically involve health professionals in the development process of VR applications. In particular, we conducted an online survey with 102 healthcare professionals based on a video prototype which demonstrates a software platform that allows them to create and utilise VR experiences on their own. For this study, we adapted and extended the Technology Acceptance Model (TAM). The survey focused on the perceived usefulness and the ease of use of such a platform, as well as the attitude and ethical concerns the users might have. The results show a generally positive attitude toward such a software platform. The users can imagine various use cases in different health domains. However, the perceived usefulness is tied to the actual ease of use of the platform and sufficient support for learning and working with the platform. In the discussion, we explain how these results can be generalized to facilitate the integration of VR in healthcare practice.

Saab et al. (2022) Indicated that their study explored nursing students' views of using virtual reality in healthcare. The popularity and use of virtual reality in healthcare delivery and education is on the rise. Yet, the views of future nurses regarding this technology remain underexplored. This is a qualitative descriptive study guided by a naturalistic inquiry and reported using the Standards for Reporting Qualitative Research checklist. Nursing students (n = 26) were recruited using convenience and snowball sampling. They were first exposed to a virtual reality intervention aimed to enhance men's awareness of testicular diseases. This was attempted to familiarise participants with the technology and initiate conversations around its use in healthcare. Participants were then interviewed face-to-face, either individually or within focus groups. Data were analysed using thematic analysis. The results found that four themes were identified: (i) positive experiences of virtual reality; (ii) challenges to using virtual reality; (iii) settings where virtual reality can be implemented; and (iv) blue-sky and future applications of virtual reality. Participants described this technology as novel, enjoyable, immersive, memorable and inclusive. They questioned, however, the suitability of virtual reality for older adults, reported minor technical difficulties and stressed the importance of prior preparation in the use of the technology. Virtual reality was recommended for use in outpatient healthcare settings, schools and the community. Participants suggested using virtual reality in health promotion, disease prevention and management, and to promote nurses' empathy towards patients. Findings highlight the potential role of virtual reality in assisting nurses in promoting health and managing disease. Future research is needed to establish the long-term effect of virtual reality interventions among more diverse participants.

Abdelmaged Mohamed and Adel Mahmoud (2021) Implementation of virtual reality in healthcare, entertainment, tourism, education, and retail sectors. Their studied found that Immersive technologies such as virtual reality is continuing to alter cross-industry applications by providing compelling user experiences throughout platforms. Virtual reality has advanced dramatically in recent years, and it is increasingly being utilized in gaming, advertising, entertainment, and staff training programs. Real-life simulations and immersive consumer experience have contributed to virtual reality's broad acceptance in the gaming and entertainment industries. AR and VR technologies appear to have significant potential in a variety of businesses. Owners of businesses could consider using immersive technologies in order to get new consumers and improve their engagement experience. This research aims to explore the applications of virtual reality in different sectors such as: healthcare, entertainment, tourism, education, and retail industries.

Mäkinen et al. (2022) The study revealed that the aim of this integrative review was to analyse the usage of different virtual reality (VR) technologies in learning and user experiences (UXs) of these technologies in healthcare practice and education. The integrative review was conducted in spring 2019 by searching eight international databases. The searches retrieved n = 26 original articles that were quality checked and included for the review. Three different VR technologies used in the field of healthcare education and practice were identified: haptic device simulators, computer-based simulations and head-mounted displays (HMDs). The haptic simulators were the most often used, whereas the HMD devices were the least-used technology in the field of healthcare. In immersive virtual environments, UX includes ten components. Most of the components were observed in the context of haptic devices and HMD devices, with all ten components being observed with the HMD devices. Almost all of the components were rated as positive. In conclusion, the development of VR technology has enabled the creation of the most comprehensive UXs, thus enhancing skill development, enabling remote access to training and, ultimately, improving patient safety. This review is important as it highlights the need for far more UX research within immersive virtual environments.

van der Kruk et al. (2022) To explore what is currently known about the use of virtual reality (VR) as *a patient* education tool in healthcare. Arksey and O'Malley's scoping review method and the PRISMA-ScR Checklist were employed. Four peer-reviewed databases were searched (Medline, Embase, PsychINFO, the Cochrane library). Pre-defined selection criteria identified 18 studies for inclusion. Results were synthesized using a narrative approach. The results shown that VR as an educational tool in healthcare is feasible and acceptable, and may improve patient's knowledge about their illness and satisfaction with treatment. Most studies used the Oculus VR glasses or headset, educated patients though the use of 3D 360° VR anatomical models, and were conducted with people affected with cancer.

Opportunities exist for exploring unintended consequences, and the role of VR in educating populations with lower health literacy. VR could assist in communicating medical information and knowledge to patients, but more research is needed, particularly to identify for whom and in what situations this method is most useful and to improve understanding about the potential unintended consequences.

Mao et al. (2021) Introduced that the immersive virtual reality (iVR) simulators provide accessible, low cost, realistic training adjuncts in time and financially constrained systems. With increasing evidence and utilization of this technology by training programs, clarity on the effect of global skill training should be provided. This systematic review examines the current literature on the effectiveness of iVR for surgical skills acquisition in medical students, residents, and staff surgeons. A literature search was performed on MEDLINE, EMBASE, CENTRAL, Web of Science and PsycInfo for primary studies published between January 1, 2000 and January 26, 2021. Two reviewers independently screened titles, abstracts, and full texts, extracted data, and assessed quality and strength of evidence using the Medical Education Research Quality Instrument (MERSQI) and Cochrane methodology. Results were qualitatively synthesized, and descriptive statistics were calculated. The literature search yielded 9650 citations, with 17 articles included for qualitative synthesis. The mean (SD) MERSQI score was 11.7 (1.9) out of 18. In total, 307 partici pants completed training in four disciplines. Immersive VR-trained groups performed 18% to 43% faster on procedural time to completion compared to control (pooled standardized mean difference = -0.90 [95% CI=-1.33 to -047, I^2=1%, $P < 0.0001$]). Immersive VR trainees also demonstrated greater post-intervention scores on procedural checklists and greater implant placement accuracy compared to control.Immersive VR incorporation into surgical training programs is supported by high-quality, albeit heterogeneous, studies demonstrating improved procedural times, task completion, and accuracy, positive user ratings, and cost-effectiveness.

Barteit et al. (2021) Found that Virtual reality (VR)-based simulation in hospital settings facilitates the acquisition of skills without compromising patient safety. Despite regular text-based training, a baseline survey of randomly selected healthcare providers revealed deficiencies in their *knowledge, confidence, comfort*, and care skills regarding tracheostomy. This prospective pre–post study compared the effectiveness of *regular* text- and VR-based *intervention* modules in training healthcare providers 'self-efficacy in tracheostomy care skills. Between January 2018 and January 2020, 60 healthcare providers, including physicians, nurses, and respiratory therapists, were enrolled. For the intervention, a newly developed head-mounted display (HMD) and web VR materials were implemented in training and clinical services. Subsequently, in-hospital healthcare providers were trained using either text or head-mounted display virtual reality (HMD-VR) materials in the *regular* and *intervention* modules, respectively. For tracheostomy care skills, preceptors directly audited the performance of trainees and provided feedback. At baseline, the degree of trainees agreement with the self-efficacy-related statements, including the aspects of *familiarity, confidence*, and *anxiety* about tracheostomy-related knowledge and care skills, were not different between the control and *intervention* groups. At follow-up stage, compared with the *regular* group, a higher percentage of *intervention* group*'* trainees reported that they are "strongly agree" or "somewhat agree" that the HMD-VR simulation increases their self-efficacy, including the aspects of *familiarity* and *confidence*, and reduced their *anxiety* about tracheostomy-related knowledge and care skills. After implementation, a higher degree of trainees*'* average satisfaction with VR-based training and VR materials was observed in the *intervention* group than in the *regular* group. Most reported that VR materials enabled accurate messaging and decreased anxiety. The increasing trend of the average written test and hands-on tracheostomy care skills scores among the *intervention* group trainees was significant compared to those in the *regular* group. The benefits of HMD-VR simulations and web-VR material-based clinical services for in-hospital healthcare providers and patient families persisted until 3 to 4 weeks later.The current study suggests that VR materials significantly enhance trainees' self-efficacy (increased familiarity, increased confidence, and reduced anxiety) and their satisfaction with the training, while motivating them to use acquired knowledge and skills in clinical practice.

Jung and Younhyun (2022) Studied of a critical component of disaster preparedness in hospitals is experiential education and training of health care professionals. A live drill is a well-established, effective training approach, but cost restraints and logistic constraints make clinical implementation challenging, and training opportunities with live drills may be severely limited. Virtual reality simulation (VRS) technology may offer a viable training alternative with its inherent features of reproducibility, just-in-time training, and repeatability. This integrated review examines the scientific evidence pertaining to the effectiveness of VRS and its practical usefulness in training health care professionals for in-hospital disaster preparedness. A well-known 4-stage methodology was used for the integrated review process. It consisted of problem identification, a literature search and inclusion criteria determination, 2-stage validation and analysis of searched studies, and presentation of findings. A search of diverse publication repositories was performed. They included Web of Science (WOS), PubMed (PMD), and Embase (EMB). The integrated review process resulted in 12 studies being included. Principle findings identified 3 major capabilities of VRS: (1) to realistically simulate the clinical environment and medical practices related to different disaster scenarios, (2) to develop learning effects on increased confidence and enhanced knowledge acquisition, and (3) to enable cost-effective implementation of training programs. The findings from the integrated review suggested that VRS could be a competitive, cost-effective adjunct to existing training approaches. Although the findings demonstrated the applicability of VRS to different training scenarios, these do not entirely cover all disaster scenarios that could happen in hospitals. This integrated review expects that the recent advances of VR technologies can be 1 of the catalysts to enable the wider adoption of VRS training on challenging clinical scenarios that require sophisticated modeling and environment depiction.

Chang et al. (2022) Studied about the effectiveness of the virtual reality chemical disaster training program in emergency nurses: A quasi experimental study found that in Taiwan, 50 % of the chemical disasters in the last decade were industrial accidents. The leakage of industrial toxic chemical substances may cause significant environmental pollution and harms. Taiwan's chemical disaster education and training mainly rely on simulation, which is labor-intensive, time-consuming, and costly. Tabletop drills are often used to as a substitute for simulations. However, tabletop drills lack a realistic presence. The 360° virtual reality (VR) transforms knowledge of disaster preparedness into audio-visual and other sensory experiences and allows participants to be physically immersed in an environment. This study examined effectiveness of a “360° VR chemical disaster training program” on disaster preparedness and self-efficacy in ER nurses. This study used convenience sampling and quasi-experimental design with two-group repeated measures. Seventy-seven ER nurses were recruited with the experimental group (n = 32) receiving chemical disaster training through 360° VR and the control group (n = 35) receiving training through tabletop drills. Data were collected before, one week after and three weeks after the intervention. The result shown that the participants in the experimental group were significantly younger and less experienced in disaster management than those in the control group. There were no between-group differences in the participants' self-assessment of chemical disaster preparedness and self-efficacy before the intervention. The intervention group showed significantly higher self-assessment chemical disaster preparedness scores than the comparison group ($p < .05$) one week after the intervention. However, no significant differences were found three weeks after the intervention. This study found that both 360° VR and tabletop drills improved preparedness and self-efficacy in chemical disasters among ER nurses. VR could be used for disaster preparedness training for nurses without prior disaster response experiences/ drills, whereas tabletop drills were more suitable for nurses with prior experiences. Both methods may effectively promote nurses' learning effectiveness and self-efficacy in chemical disaster preparedness.

Loke et al. (2021) studied of the development of disaster nursing education and training programs in the past 20 years (2000–2019): A systematic review emerged that the nurses play a pivotal role in disaster management across the globe. With the call for all nurses to be prepared for disasters, disaster nursing education and training programs have expanded globally. However, a clear picture of the development and coverage of disaster nursing education and training programs is lacking. This study aimed to establish an overall picture of the development of disaster nursing education and training programs in the last 20 years, outline the contents included, approaches adopted and outcomes reported. A systematic search for relevant literature published between January 2000 to December 2019 was conducted using electronic databases including the CINAHL, MEDLINE, PubMed, Web of Science, and Scopus with the keywords on disaster nursing education and training. Their findings of a total of 75 eligible studies were identified from 3395 potentially relevant articles. The numbers of disaster nursing education and training programs increased gradually over the past 20 years. They were offered in various countries with an unbalanced geographical distribution. Most of the existing programs focused on disaster preparedness and response, especially on the skills of triage during disaster response, instead of addressing the full spectrum of disaster management that included mitigation, preparedness, response, and recovery phases. Multiple approaches and technologies were adopted, including competency-based, all-hazard, inter-professional, flipped classroom, simulation, tabletop exercises, and virtual reality ones. Nearly half of the included programs adopted a pre- and post-test evaluation to examine the outcomes of learning and all of the programs reported significant increases in nursing professionals' knowledge and skills of related content on disaster management covered in the training programs. This review provides nurse leaders, educators and researchers in nursing with an understanding of the state-of-art of the existing disaster nursing education and training programs. More disaster nursing research are necessary to enhance the knowledge, skills and readiness of the nursing professionals for disaster management in meeting global disaster challenges.

The integration of Virtual Reality (VR) technology into disaster preparedness and emergency response training has emerged as a transformative force in both educational and healthcare domains. This literature review reveals a growing body of evidence that supports the potential of VR to revolutionize how individuals and professionals acquire, retain, and apply critical rescue skills in simulated high-risk environments. Globally, studies have consistently demonstrated that VR enhances the realism, immersion, and interactivity of training, contributing to increased learner engagement, improved knowledge retention, and greater self-efficacy. From simulated earthquake and fire scenarios to advanced applications in surgical and nursing education, VR platforms have been shown to facilitate experiential learning through controlled, repeatable, and safe environments. Moreover, VR enables learners to practice critical procedures without risking real-life consequences—an especially valuable attribute for high-stakes situations like disaster management. However, while the literature supports the effectiveness of VR in healthcare and emergency training contexts, several critical gaps remain. Notably, there is limited research exploring the application of VR in large-scale public education settings such as disaster prevention museums or national training centers. Furthermore, few studies have addressed the comparative effectiveness of VR versus traditional training methods in terms of learning efficiency, behavioral change, and the social impact of knowledge dissemination. These gaps highlight the significance of this thesis, which investigates VR-based emergency rescue training in a real-world public education setting—the Sichuan Disaster Prevention and Reduction Museum. This study contributes to the growing discourse by providing empirical evidence on the role of VR in enhancing disaster preparedness, particularly among the general public, through immersive, interactive experiences. By addressing these unexplored areas, this research not only adds depth to the academic understanding of VR applications in disaster education but also offers practical guidance for the broader adoption and implementation of such technologies in public safety programs. In sum, the existing literature lays a strong foundation for VR's role in training and education, yet it simultaneously calls for targeted research into its contextual application, cultural adaptability, and long-term efficacy in public disaster response systems. This thesis aims to bridge this gap by evaluating the practical implications and transformative potential of VR within a widely accessible and socially impactful context.

2.7 Research Framework

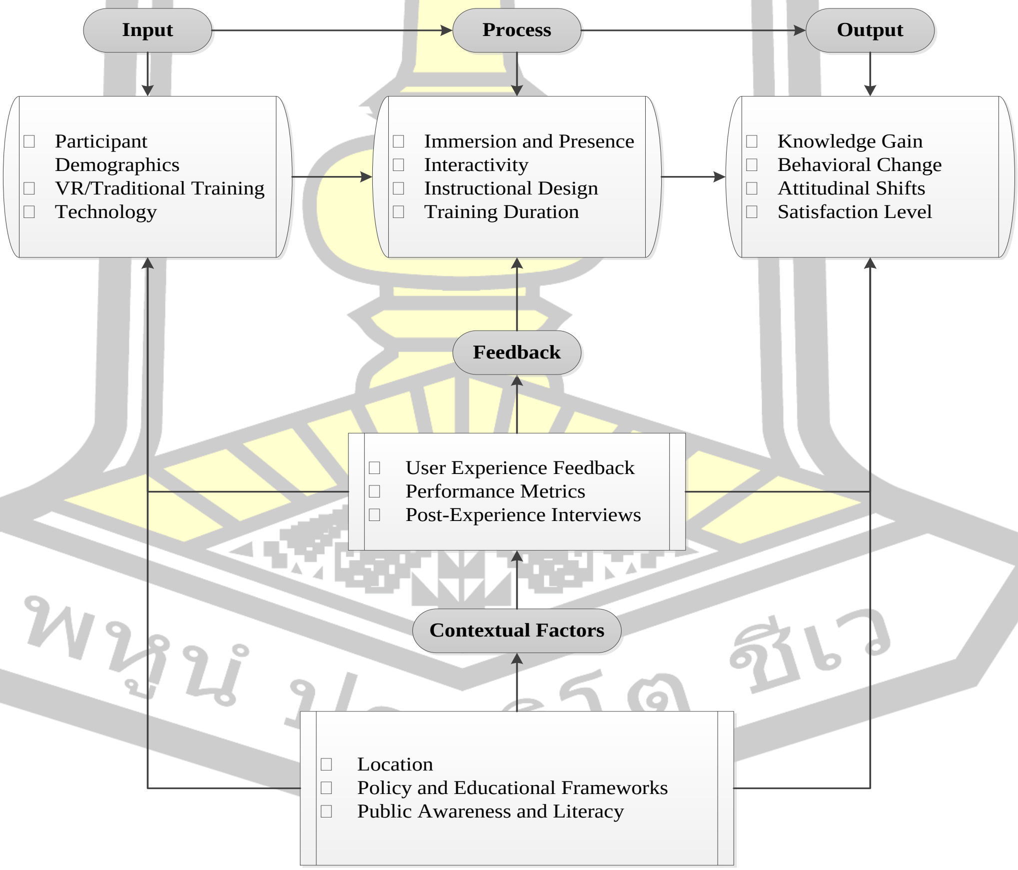

Figure 1 The research framework of the application of VR technology in the Sichuan Disaster Prevention and Reduction Museum

CHAPTER III
RESEARCH METHODOLOGY

3.1 Research methods

This study undertakes an in-depth investigation into the application of virtual reality (VR) technology at the Sichuan Disaster Prevention and Reduction Museum. The research employs a quasi-experimental research design integrating both quantitative and qualitative data collection methods.

3.1.1 Quantitative part

The questionnaire survey method was adopted. The questionnaire QR code was set up at the study site via the Question star software, and the questionnaires were collected by the volunteer participants who scanned the code and provided answers on the Internet, to understand the trainees' grasp of the training content and knowledge and focus on their cognition and satisfaction with the effectiveness, experience, and application effect of mastering the same knowledge.

3.1.2 Qualitative part

The interview method and observation method were adopted: Through individual or group interviews, as well as participants' observation records in the virtual reality training process, information is collected to gain an in-depth understanding of the role and impact of virtual reality technology in emergency education and training.

3.2 Sample collection method

3.2.1 Study population and sample

The sample group in this instance are the visitors to the Sichuan Disaster Prevention and Reduction Museum and the learners of disaster prevention and reduction knowledge public welfare lecture hall. Sichuan Disaster Prevention and Reduction Museum, as a public welfare disaster prevention and reduction education museum is open to the whole society, with no limit on the number of visitors, reflecting the popularity and popular demand of this study. The museum receives a maximum of 400 visitors per day, about 10,000 people per month, regardless of age, and from all walks of life. This study will spend two months collecting data from the samples in the museum. Without considering public holidays, the sampling time will be about 40 days, with an average of 8 to10 samples collected daily.

3.2.2 Sample size

Study participants are all eligible individuals who visited the Sichuan Provincial Disaster Prevention and Mitigation Education Museum. The study’s sample size is calculated using the survey formula according to the scale formula, as follows:

$$n = Z^2[p(qp)] / e^2$$

This works if:

- n is the sample size

- Z^2 is the horizontal coordinate of the normal curve, cutting off the area α at the tail (1-α equals the desired confidence level). We need a 95% confidence level. Therefore, the value of Z can be found in the statistical table containing the area under the normal curve, 1.96.

- p is the estimated proportion of an attribute in the population. Through consulting relevant literature, there is no relevant literature on the knowledge awareness rate of disaster prevention and reduction of the masses in Sichuan Province. After consulting the Sichuan Fire Protection Association, the conclusion is that about 27 million people in Sichuan Province have popularized the knowledge of fire prevention and disaster reduction (see Figure 1). As of 2021, the population of Sichuan Province is about 83.72 million (Figure 2). Therefore, the popularization of fire protection and disaster prevention and reduction in Sichuan Province accounts for about 30% of the total population of the province (p-value = 0.30)

- q = 1-p = 1-0.30 =0.7

- e is the desired accuracy level. We require ±5% accuracy.

Therefore, by substituting the results into the formula, the sample size is:

$$= [(1.96)(0.3)(0.7)] / (0.05)^2 \approx 322.69$$

Based on this result, we will select n = 323 participants. However, we need a sample size of more than 10% to exclude those who do not agree to continue to participate in the study or those who are not qualified, due to certain reasons, and because we need to compare the conventional teaching method with the VR teaching method and set the participation group and the comparison group, the participant data needs to be even. Therefore, the minimum sample size for this study was n = 323 + 10%*323 = 356 participants.

3.2.3 Inclusion criteria

Participants must meet the following criteria to be included in the study:

1) General Eligibility

- Must be at least 18 years old and capable of providing informed consent.

- Minors (under 18) may participate with explicit parental or guardian consent and supervision.

2) Physical and Cognitive Ability to Engage in VR Training:

- Must have normal or corrected-to-normal vision (e.g., glasses or contact lenses) to effectively interact with VR content.

- Must not have any severe medical conditions (such as epilepsy, vertigo, or severe motion sickness) that could interfere with VR participation.

3) Participation in Disaster Preparedness Training:

- Must be a visitor to the Sichuan Disaster Prevention and Reduction Museum and willing to engage in emergency training activities.

- Must have no prior formal training in VR-based emergency rescue simulations to ensure unbiased evaluation.

4) Technological Accessibility:

- Must be able to operate basic VR equipment or be willing to receive a brief orientation on VR usage.

- Must be willing to complete pre- and post-training assessments to measure learning outcomes.

5) Control Group Specific Criteria:

- Participants assigned to the control group must agree to participate in traditional classroom-based disaster preparedness training instead of VR-based training.

- Must not have prior exposure to VR-based emergency training programs.

Therefore:

The first group is the experimental group. Subjects were randomly selected from visitors to the Disaster Prevention Museum. Due to the large amount of data required for this survey, the universality is strong, and the people are targeted, so there is no gender, age, occupation, or other requirements and restrictions as long as the group can use VR normally. However, participants must participate in the VR escape experience of the Disaster Reduction Museum and agree to participate in the study after understanding the purpose of the study and scanning the questionnaire's QR code.

Although the study is not limited by gender, age, or occupation, it is recommended that participants be adults under the age of 60, minors under 18 years old, and adults over 18 years old. Those born before 2006 must be in good health to participate in their studies. Minors should be accompanied by a guardian and obtain the guardian's permission to participate, and the scanning of the two-dimensional code of the questionnaire requires the guardian to complete the questionnaire content.

The second group was the control group, and subjects were randomly selected from the trainees who participated in disaster training in the offline disaster prevention and Reduction public welfare lecture hall of the Disaster Reduction Museum. Due to the large amount of data required for this survey, the universality is strong, and the people are targeted, so there are no gender, age, occupation requirements, and restrictions. Due to the need to compare the learning effects of the experimental group and the control group, the control group can only participate in the offline disaster classroom teaching, and cannot participate in the VR disaster experience teaching at the disaster reduction museum. Similarly, the control group participated in the study after understanding the purpose of the study and agreeing to participate in the scan able questionnaire QR code. Though the study is not limited by gender, age, or occupation, it is recommended that adult participants should be under the age of 60 but over 18 years of age and minors under 18 years old. Minors who wish to partake in the study should obtain the guardian's permission before and be accompanied by the guardian during the participation. The scanning of the two-dimensional code of the questionnaire requires the guardian to complete the questionnaire content. Those born after 1964 and are over the age of 60 should be in good health.

3.2.4 Exclusion criteria

Participants will be excluded from the study if they meet any of the following criteria:

1) Medical Conditions Limiting Participation:

- Individuals with severe cardiovascular or cerebrovascular diseases, hypertension, epilepsy, vertigo, or other medical conditions that may be aggravated by VR exposure.

- Pregnant individuals who may experience discomfort or risk due to VR-induced dizziness.

- Individuals with significant visual impairments that cannot be corrected with glasses or contact lenses, affecting their ability to engage with VR training.

2) Professional Expertise in Emergency Training:

- Firefighters, paramedics, emergency responders, disaster management professionals, or educators specializing in emergency preparedness, as they already possess advanced knowledge and skills in disaster response.

3) Cognitive or Physical Limitations Affecting VR Interaction:

- Individuals with severe physical disabilities that prevent them from properly using VR equipment.

- Those with cognitive impairments or mental health conditions that could hinder comprehension, engagement, or ability to follow safety instructions during VR training.

4) Minors Without Guardian Consent:

- Participants under the age of 18 who do not have explicit consent from a parent or legal guardian.

- Minors who do not have a guardian present to assist with questionnaire completion and participation requirements.

5) Previous Participation in Similar VR-Based Studies:

- Individuals who have recently (within the past six months) participated in similar VR disaster preparedness training programs, which may bias the study results.

6) Reluctance or Inability to Provide Informed Consent:

- Individuals unwilling or unable to provide informed consent for participation in the study.

- Those who decline to complete pre-training and post-training assessments necessary for evaluating learning outcomes.

3.3 Research time

The study have been conducting from March 2024 to September 2024 (six months).

3.4 Study site

Sichuan Disaster Prevention and Reduction Museum is located at No. 260, Section 2, Wuyang Avenue, Wuhou District, Chengdu, covering a total area of 17.71 mu, with a total construction area of 12,016 square meters and a total investment of 144 million yuan (RMB). The overall planning area of the exhibition area is 7,000 square meters, with disaster feeling area, disaster understanding area, disaster prevention and relief area, children's experience area, and temporary exhibition area. The forecast daily reception is 1400 people, and the annual reception is about 500,000 people.

Figure 2 Actual picture of Sichuan Disaster

Figure 3 Prevention and Reduction Museum

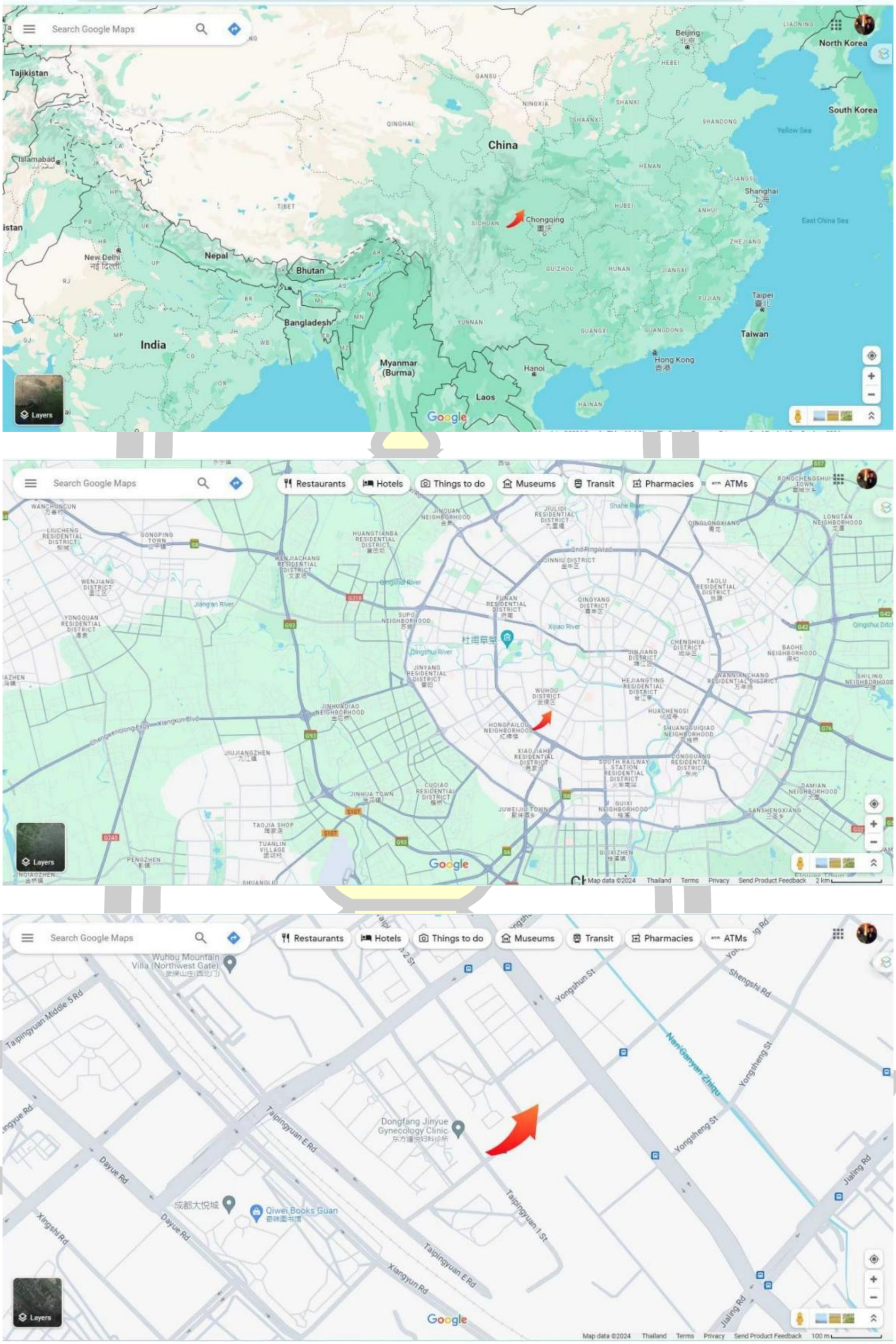

Figure 4 Location map of Sichuan Disaster Prevention and Reduction Museum

Sichuan Disaster Prevention and Reduction Museum VR Experience Project Introduction: The VR fire escape scene experience project offers a multi-user VR experience within a spacious environment of 100 square meters. This space is segmented into distinct areas which include a safety zone, equipment room, and control center. Within the 7m x 7m safety area, up to 10 participants can do integrated VR headsets and engage in free movement, equipment operation, and collaborative tasks within a virtual fire scenario facilitated by Inside Out space positioning technology. With the incorporation of high-fidelity simulations of smoke, flames, 3D positional audio, and physical feedback mechanisms, the project aims to deliver an immersive and interactive experience, fostering a sense of realism and teamwork among players. Additionally, spectators in the waiting area can observe the virtual scene on a large screen, gaining insight into the immersive experiences of the participants.

Participants are tasked with navigating a virtual office building engulfed in flames, encountering various emergency scenarios such as blocked exits, smoke inhalation, jammed doors, and obstructed escape routes. They are required to apply their knowledge of fire safety and utilize props available on the scene, including fire alarm buttons, extinguishers, masks, axes, and safety lights, to navigate safety and initiate emergency response measures.

By leveraging advanced multiplayer VR technology, the project offers engaging and novel experience for the participants. The immersive nature of the scenario fosters heightened awareness of fire hazards while providing a platform to practice and refine fire response strategies, escape techniques, and psychological resilience. With its comprehensive coverage, interactive elements, and practical tasks, the project facilitates a transition for the audience from passive observers to active participants, enhancing their understanding of fire safety principles, proficiency in utilizing firefighting equipment, and practical skills in fire evacuation procedures.

Figure 5 Landscape of VR experience room of Sichuan Disaster Prevention and Mitigation Education Museum

Figure 6 VR gadgets at Sichuan Disaster Prevention and Reduction Museum

Figure 7 VR fire scene at the Sichuan Disaster Prevention and Reduction Museum

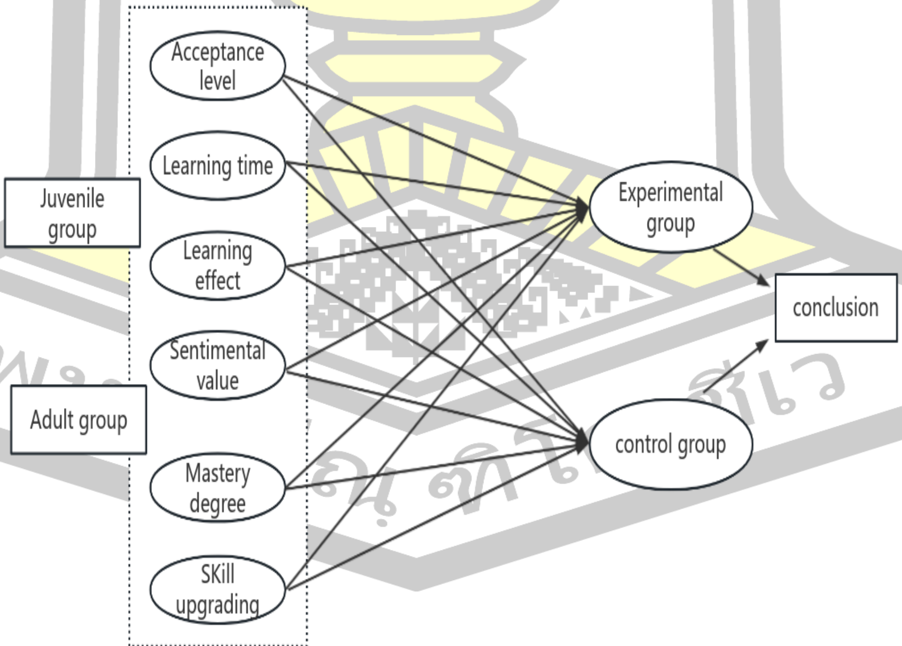

Figure 8 Group and contrast content illustrations

3.5 Research variables

In this study, the following variables will be assessed to evaluate the impact of Virtual Reality (VR) training on emergency rescue skills and disaster preparedness:

Independent Variable:

- Training Method: VR-based emergency rescue training (experimental group) and Traditional classroom-based training (control group)

Dependent Variables:

- Knowledge Acquisition: Pre- and post-training assessments on disaster awareness and emergency response skills. Retention of knowledge over time.

- Skill Performance: Ability to execute proper emergency response techniques. Time taken to complete fire escape or self-rescue simulations.

- Behavioral and Attitudinal Changes: Confidence levels before and after training. Changes in risk perception and preparedness for real-life disaster scenarios.

- User Experience and Engagement: Participants' satisfaction with the training method. Perceived ease of use and comfort of VR technology.

Control Variables:

- Demographic Factors: Age, gender, education level, and occupation of participants. Prior experience with emergency training and disaster response.

- Technological Familiarity: Previous exposure to VR technology. Frequency of using digital learning tools.

- Environmental Factors: Training duration and setting (VR vs. traditional). Presence of external distractions during the training session.

3.6 Data Collection Methods

3.6.1 In terms of data collection, we adopt two methods

Study Group: The questionnaire QR code was prominently displayed in the VR experience area of the Sichuan Disaster Prevention and Reduction Museum. Trained research personnel were stationed on-site to provide explanations and guidance to visitors, informing them that the study focuses on the application of digital technology in emergency training. Visitors who met the eligibility criteria and expressed willingness to participate were invited to scan the QR code and complete the questionnaire. To ensure privacy and confidentiality, no personal identifying information (e.g., names, addresses, or contact details) was collected. For participants who encountered technical difficulties with the QR code or questionnaire software, research staff provided assistance as needed.

Figure 9 QR code and live commentary

Control Group: The Sichuan Disaster Prevention and Reduction Museum regularly conducts public welfare lectures on disaster prevention and preparedness. During these sessions, research information was shared with participants, encouraging voluntary participation in the study. All participants were informed about the study's purpose, procedures, and their rights to voluntarily participate or withdraw at any time.

To join the study, individuals were given the option to scan a QR code or access a secure online link to complete the questionnaire. For student participants, QR code scanning was permitted in groups with teacher supervision, ensuring both convenience and diversity in sample collection. As offline data collection was not conducted for the control group, a broader audience was reached through public welfare lecture groups on social media platforms. These groups provided detailed study information, including the research objectives, methods, and voluntary participation guidelines. Interested participants who met the eligibility criteria were invited to join the study remotely.

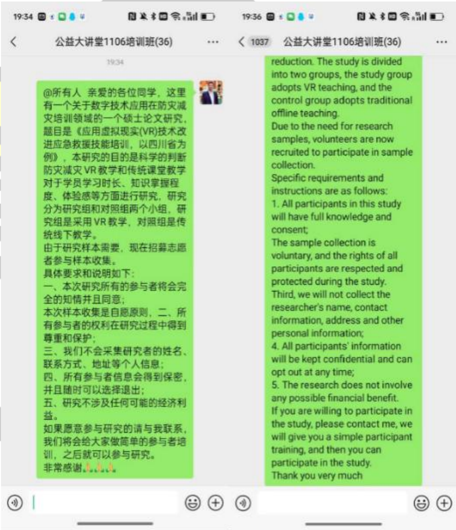

Figure 10 Volunteer recruitment information is available in Chinese and English

We provided a comprehensive introduction to the research methodology for participants in both the experimental and control groups. This introduction included a brief training session outlining the research purpose, study content, and sampling methods to ensure clarity and informed participation.

The experimental group engaged in virtual reality (VR) experiential training, while the control group received traditional classroom-based instruction. Although the teaching methods differed, the intervention procedures remained consistent, ensuring uniformity in study conditions and assessment across both groups.

3.6.2 Expert Review

The draft questionnaire has been translated into Chinese and English. The questionnaire was then sent to five experts with doctoral degrees or above in health and safety or virtual reality research. After getting their consent, we will ask them to help confirm the accuracy of the voucher. Their assistance would be noted upon completion of the paper.

List of participating experts:

- Professor He Zhongjie, director of ICU of 304 Hospital of PLA and founder of Platinum ten-minute prescription emergency theory.

- Dr. Wang Bing, former Commander of the Chinese peacekeeping Force in Liberia of the United Nations Mission in Africa.

- Professor Luo Hongsen, Director of the Institute of Public Security and Emergency Response, Sichuan Normal University.

- Member of China Computer Society CCF, Professor Liu Jianyang, School of Mechanical Engineering, Southwest Jiaotong University.

- Dr. Zhang Ling, Director of the Public Welfare Promotion Center of Sichuan Disaster Prevention and Mitigation Education Center.

3.6.3 Data Collection Procedure

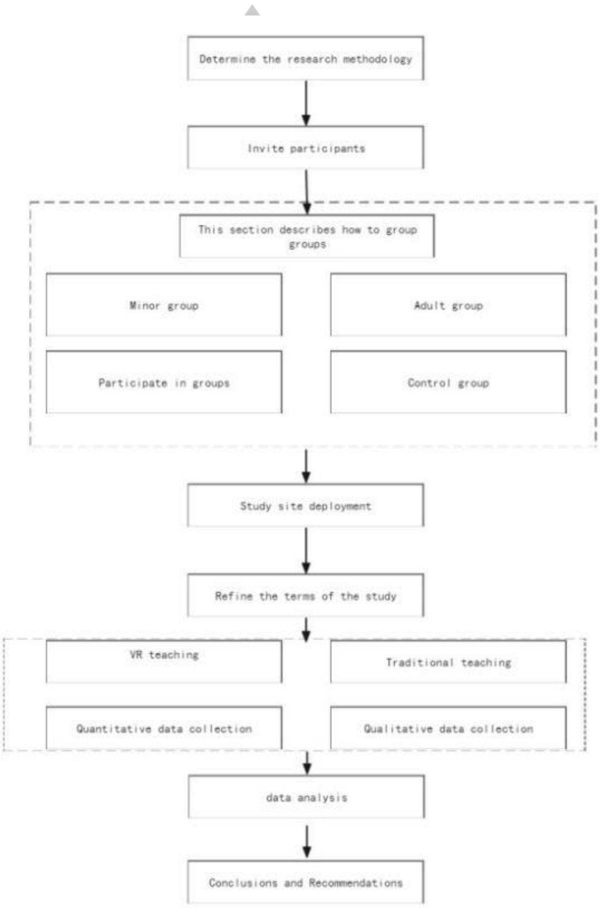

Figure 11 Data collection methods and processes

3.6.4 Phase 1

Step 1: We divided a total of 356 eligible participants into two groups, the experimental group and the control group, with 178 samples in each group.

Experimental group: For the experimental group, the questionnaire is divided into three parts:

- Part One: Basic personal information, which includes gender, age, etc.

- Part Two: Prior-experience information. The participant's mastery of Virtual Reality technology and the expected judgment of teaching duration when not participating in the experience.

- Part Three: Post-experience information. After experiencing fire escape and self-rescue through VR, participants had a better understanding of things. The experimental group tests were designed to assess participants before and after learning virtual reality technology. Before the experience, we merely understand the participants' grasp of VR, disaster prevention and reduction knowledge, and other basic information, and whether they have participated in disaster learning and other basic information. We mainly selected participants who used VR equipment for disaster knowledge learning for the first time and tested their teaching effects by using post-test tables after VR teaching activities.

Control group: The questionnaire for the control group was divided into two parts.

- Part One: Basic personal information, which included gender, age, etc.

- Part Two encompassed virtual reality information. To understand the control group's grasp of virtual reality, the expected value of virtual reality disaster education, and the expected judgment of teaching time were considered.

The prediction table of the control group consisted mainly of the cognition degree of the control group's knowledge of disaster prevention and reduction, and whether the control group had learned about national disasters online or offline, especially fire knowledge. In particular, it was pointed out that the non-systematic learning of various public welfare publicity would be included in the list of subjects for non-participants of the research. The criteria for the participants were based on their offline learning of escape knowledge for the first time. They were tested with a questionnaire after their studies.

Step 2:

- Sample selection method of participant group: We posted a poster of a questionnaire survey on two-dimensional code in the VR experience area of the Sichuan Disaster Prevention and Reduction Museum and then explained the topic to tourists who planned to have VR experience and solicited their opinions on whether they were willing to participate in the study. Willing participants would serve sample results for the group and scan the two-dimensional code with their mobile phones to participate in the study. In addition, answer the first and second parts of the questionnaire before VR experience, and answer the third part of the questionnaire after the VR experience. Participation or non-participation in the questionnaire does not affect the VR experience of Sichuan Disaster Prevention and Reduction Museum.

- Sample selection method for the control group: We published research information among the students who participated in the public welfare lecture hall at the Sichuan Disaster Prevention and Reduction Museum, hoping that the students could participate in the research. Participants will be informed of the purpose of the voluntary study. Participants can scan the QR code or click the link to enter the questionnaire.

3.6.5 Phase 2

Step 3: Experimental group test: With interviews and surveys, the subjective experience of participants in the VR fire escape and self-rescue experiential teaching at the Sichuan Disaster Prevention and Mitigation Museum from June 20, 2024 to August 20, 2024 was discussed. Participants' behavior data was recorded when using VR, such as time spent, interaction frequency, teaching duration, teaching effect, etc., and relevant opinions and suggestions. A post-test was carried out to evaluate the efficiency, effect and the emotions of participants in the fire scene escape knowledge teaching activities using virtual reality technology, especially the time to completely master the learning process is the focus of this study.

Step 4: Control group test: The relevant facts of the participants were scrutinized in the offline fire escape and avoidance learning at the Disaster Prevention and Mitigation Public Lecture Hall of Sichuan Disaster Prevention and Reduction Museum from June 20, 2024 to August 20, 2024. The efficiency, effectiveness, and emotional levels of the personnel during the offline fire escape and hedge knowledge teaching activities were evaluated. The time taken to complete the study and fully grasp the knowledge of escape and risk was the focus of this study. Through the subjective experience of students' offline teaching, the behavioral data of participants in regular classroom teaching, such as teaching time, offline interaction, teaching effect, etc., were explored as well. At the same time, we also conducted a questionnaire survey on the control group's understanding of virtual reality technology and their expectations for virtual reality teaching.

Figure 12 The behavior of the experimental group was interviewed and observed

Figure 13 Participants filled out questionnaires

Note: As the museum is open to the general public, minors can also visit the museum. Therefore, minors may be present in the pictures we select. However, minors were excluded from the research sample, and only adults who could register for the questionnaire on Wenjuanxing using their mobile phones were selected for the questionnaire survey.

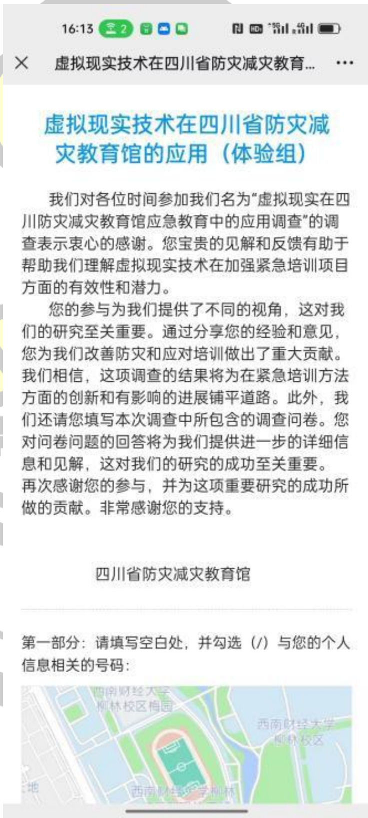

Figure 14 The opening of the questionnaire survey is for introduction

3.6.6 Phase 3

Step 5: Screen the survey samples to eliminate those that do not meet the requirements, ensuring that the remaining samples align with the research objectives. Based on the number of discarded samples, continue sampling to maintain both the quantity and quality of the samples.

Step 6: The study analyzes the teaching effectiveness of an experimental group and a control group, with both focused on the same disaster scenario, specifically a fire scene. It investigates whether the learning outcomes from virtual reality (VR) teaching differ from those achieved through traditional methods. The comparison is made based on teaching duration, knowledge retention, and emotional engagement in learning.

3.6.7 Error Control Measures

During investigation, the selection of samples is crucial. Participants must partake in the implementation plan, complete the questionnaire, and exclude unqualified samples to ensure an accurate reflection of the purpose of the remaining samples in the study. At the same time, with the discarded samples, it is necessary to continue sampling to ensure the quantity and quality of the samples. In this way, the accuracy and reliability of the research results can be achieved. Therefore, the continuous monitoring of the sample screening process, and making appropriate adjustments as needed, is an important step to ensure that the study runs smoothly and reliable conclusions are reached. Samples must meet selection and exclusion criteria.

3.7 Data Analysis

Data collection for both groups was conducted simultaneously at the Sichuan Disaster Prevention and Reduction Museum, where participants voluntarily joined the study after being informed of its purpose and procedures. As anticipated, the control group successfully reached its target sample size of 178 participants, completing their training through conventional classroom instruction. However, the experimental group exhibited significantly higher engagement and participation in the VR-based training sessions. By the end of the data collection period, a total of 293 participants had voluntarily enrolled and completed the VR training, surpassing the initial target by 115 additional samples.

This study employs a quantitative data analysis approach, primarily utilizing survey data collected through Questionnaire Star and analyzed using SPSS (Statistical Package for the Social Sciences). Various statistical techniques are applied to ensure a comprehensive evaluation of the data, allowing for a detailed assessment of the effectiveness of Virtual Reality (VR) training in disaster preparedness.

Questionnaire Data Processing: Questionnaire Star was utilized for the distribution, collection, and preliminary processing of survey responses. The platform facilitated the basic statistical summarization of participant data, including response frequencies, percentage distributions, and graphical representations. This enabled an initial overview of the dataset before conducting more advanced statistical analyses.

Statistical Analysis Using SPSS: To ensure a rigorous examination of the study findings, data were imported into SPSS for further analysis. The following statistical methods were applied: Descriptive Statistical Analysis used to summarize demographic characteristics, response patterns, and participant engagement levels. Mean, standard deviation, and percentage distributions were calculated to provide a comprehensive overview of the data. Cross-Tabulation and Chi-Square Test: To determine whether there were statistically significant differences between the experimental group (VR training) and control group (traditional training), a cross-tabulation analysis was conducted. The Chi-square test, a non-parametric statistical method, was used to assess associations between categorical variables (e.g., differences in VR engagement based on gender, prior experience, or confidence levels). The significance level was set at 1% (p-value < 0.01), meaning that if the calculated Chi-square value exceeded the critical threshold, the null hypothesis was rejected with 99% confidence, indicating a statistically significant association. To explore the relationships between key study variables, Pearson's correlation coefficient or Spearman's rank correlation coefficient was applied, depending on the distribution and nature of the data. A significance threshold of 0.05 (p-value < 0.05) was set to determine whether a statistically significant correlation existed between variables such as training effectiveness, knowledge retention, and confidence levels post-training. By employing these robust statistical techniques, this study ensures the reliability and validity of findings, providing a data-driven assessment of the impact of VR-based disaster training on participant knowledge, skills, and preparedness.

3.8 Research Ethics

The ethical requirements for participants in this paper are to ensure that the rights of participants are respected, protected, and upheld during the research process. We inform all participants in writing of the purpose, process, and expected results of this study prior to obtaining their informed consent and have them known that their participation will not affect any future professional relationships with current emergency education providers or researchers. This research survey was conducted in good faith, always respecting and ensuring the privacy of participants and personal information. All researchers adhere strictly to the principles of ethics, harmlessness, legality, free will, and integrity. For study participants, we inform them precisely of the purpose, process, and timing of the study, as well as the roles, obligations, and rights of the participants. We also informed them of possible risks and discomfort. As all were willing participants, their personal information will be kept confidential, with the prerogative of opting out at any time. To ensure confidentiality, we do not collect participants' names, contact information, home addresses, and other information to protect their identities. Data is stored in a secure, encrypted system that prohibits unauthorized access. Any unapproved research or third-party commercial use will not be permitted for the information.

This study was conducted in compliance with ethical research standards to ensure the rights, safety, and confidentiality of all participants. Prior to data collection, ethical approval was obtained from the Institutional Review Board (IRB) of Mahasarakham University, with the approval number 659-589/2024. Participants were fully informed about the study objectives, procedures, potential risks, and benefits before providing their informed consent. Participation was entirely voluntary, and individuals retained the right to withdraw at any stage without consequence. Additionally, to protect participant privacy and confidentiality, no personally identifiable information (such as names, addresses, or contact details) was collected. The study adhered to ethical guidelines outlined by Mahasarakham University's IRB, ensuring compliance with international ethical research principles, including the Declaration of Helsinki and Good Clinical Practice (GCP) standards.

3.8.1 Authorization Procedures

This study is critical to ensure the legitimacy and ethics of the research. We place great significance on following specific authorization procedures to ensure that the rights of participants are not compromised in any way and that the research process complies with ethical standards. Before commencing a study, it is imperative for us to submit a request for ethical review to the Ethics Committee of Mahasarahan University, including the study protocol, study objectives, methods, participant recruitment plan, data collection and processing methods, potential risks, and safeguards.

The site of this study is Sichuan Disaster Prevention and Reduction Museum, so it also needs to get the consent of Sichuan Disaster Prevention and Reduction Museum. Appreciation of efforts will be duly noted after the completion of the paper.

Upon submission of the dissertation, field research is carried out after approval by the Ethics Committee of Mahasarahan University.

CHAPTER IV
RESULTS

4.1 Introduction to the Study and Sample Collection Process

This study investigates the application of Virtual Reality (VR) technology in disaster prevention education, with a focus on its effectiveness in enhancing emergency rescue skills and preparedness. The research employs a quasi-experimental design, comparing the impact of VR-based training with traditional classroom-based training. To ensure a comprehensive and statistically robust analysis, the initial study plan aimed to collect a total of 356 samples, with an equal allocation of 178 participants to the experimental group (VR training) and 178 participants to the control group (traditional training). The goal was to achieve a balanced comparison of learning outcomes, skill acquisition, and participant engagement between the two training methods.

4.2 Demographic Characteristics of Participants

Display of the experimental results: The demographic distribution of participants highlights diversity in gender, age, educational background, and occupation, ensuring that the study captures insights from a broad spectrum of individuals. The analysis of demographic variables allows for a comparison of learning outcomes across different subgroups, helping to determine whether specific demographics influence the effectiveness of VR training.

Gender Distribution: The majority of participants were female (73.04%), while males accounted for 26.96%. This suggests that female participants were more engaged in the study or that they showed a higher interest in VR-based disaster preparedness training. The gender distribution may also influence training preferences and learning outcomes, which will be analyzed further in subsequent sections.

Educational Background: Participants in the study had diverse educational backgrounds, ranging from lower than high school education (8.53%) to doctoral degrees (1.02%). The largest proportion of participants held a bachelor’s degree (38.57%), followed by those with a junior college diploma (26.28%). A notable 12.29% held a master’s degree, while 9.56% had completed high school.

The presence of participants with varying levels of education allows for a more comprehensive analysis of how educational attainment influences knowledge retention and skill acquisition in VR-based training compared to traditional methods.

Employment Status: Employment data revealed that the largest group of participants were enterprise workers (45.39%), followed by civil servants and public service employees (27.65%). Unemployed individuals accounted for 15.7%, while students made up 11.26% of the sample.

Marital Status: Most participants were married (78.5%), followed by unmarried individuals (16.72%), and a small proportion of divorced participants (1.71%). A small percentage (3.07%) did not provide responses regarding their marital status. (See table 1)

Table 1 The socioeconomic information of the experimental study groups

Items/Variables		Number of people	Percentage
Gender	Male	79	26.96%
	Female	214	73.04%
Education	Lower than high school	25	8.53%
	High school or equivalent	28	9.56%
	Junior college	77	26.28%
	Bachelor's degree	113	38.57%
	Master’s degree	36	12.29%
	Doctors’ degree	3	1.02%
	Do not want to answer	11	3.75%
Employment status	Students	33	11.26%
	Enterprise worker	133	45.39%
	Civil servants, Public, and in the service	81	27.65%
	Unemployment	46	15.70%
Marital status	Unmarried	49	16.72%
	Married	230	78.5%
	Divorced	5	1.71%
	Missing data	9	3.07%

Socioeconomic Information of the Control Group

The demographic profile of the control group (traditional classroom-based training) provides key insights into the composition of participants and helps in comparing the effectiveness of traditional disaster education methods with VR-based training.

Gender Distribution: The control group consisted of 61.8% female participants and 38.2% male participants. While the female participation rate was lower than that of the experimental group (73.04%), women still represented the majority. The higher engagement of female participants in both groups may suggest a greater interest in emergency preparedness training among women or a higher availability of female participants during data collection.

Educational Background: The control group included participants from a wide range of educational backgrounds, with the highest proportion having junior college diplomas (41.01%), followed by bachelor's degree holders (35.96%). A smaller percentage of participants held master's degrees (9.55%), while only 0.56% had doctoral qualifications. A notable difference between the control and experimental groups is the lower representation of high school graduates and below in the control group (8.42% vs. 18.09% in the experimental group). This suggests that the traditional training format may have been more appealing to individuals with higher education levels, or it may indicate a sampling variation between the two groups.

Employment Status: The employment status distribution indicates that the majority of participants were enterprise workers (49.44%), followed by civil servants, public employees, and military personnel (34.83%). The unemployed group accounted for 15.17%, while students represented only 0.56% of the control group. A key difference compared to the experimental group is the significantly lower student participation (0.56% vs. 11.26%). This suggests that traditional classroom-based training may not have been as engaging for students, or that students were more inclined to explore immersive VR-based training.

Marital Status: Most participants in the control group were married (70.79%), followed by unmarried individuals (20.22%). Divorced participants made up 5.06%, while 3.93% of responses were missing. Compared to the experimental group, the control group had:

- A higher proportion of divorced participants (5.06% vs. 1.71%).

- A lower percentage of married individuals (70.79% vs. 78.5%).

- A higher percentage of unmarried participants (20.22% vs. 16.72%).

These variations may influence perceptions of disaster preparedness and response training, as married individuals with families may have stronger motivations for acquiring emergency response skills. (See table 2)

Table 2 The socioeconomic information of the control group

Items/Variables		Number of people	Percentage
Gender	Male	68	38.2%
	Female	110	61.8%
Education	Lower-than-high school	2	1.12%
	High school or equivalent	13	7.30%
	Junior college	73	41.01%
	Bachelor's degree	64	35.96%
	Master's degree	17	9.55%
	Doctors' degree	1	0.56%
	Do not want to answer the questions	8	4.49%
Employment status	Student	1	0.56%
	Enterprise worker	88	49.44%
	Civil servants, Public, and those in the military service	62	34.83%
	Unemployment	27	15.17%
Marital status	Unmarried	36	20.22%
	Married	126	70.79%
	Divorced	9	5.06%
	Missing data	7	3.93%

Implications of Socioeconomic Findings

- The higher participation of students in VR training suggests that younger learners may be more inclined toward immersive and technology-driven training methods.

- The higher proportion of enterprise workers in both groups highlight the practical relevance of emergency training for workplace safety and professional development.

- The greater representation of married individuals in the VR group may indicate that family responsibilities increase motivation for disaster preparedness.

The higher level of engagement from women in both training formats suggests that disaster training initiatives should consider targeted outreach to female audiences. (table 3)

Table 3 Comparison Between Experimental and Control Groups

Variable	Experimental Group (VR Training)	Control Group (Traditional Training)	Key Differences
Female Participation	73.04%	61.8%	Higher female participation in VR training
Higher Education (Bachelor's & Above)	51.88%	46.07%	Higher-educated individuals in the VR group
Student Participation	11.26%	0.56%	VR training attracted more students
Enterprise Workers	45.39%	49.44%	Similar proportions in both groups
Married Participants	78.5%	70.79%	More married individuals in VR training

4.3 The questionnaire results

- View on virtual reality technology

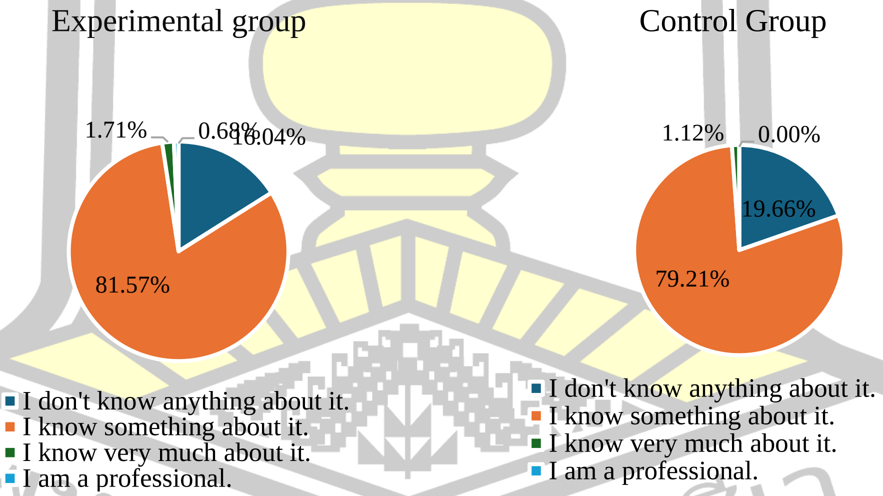

Figure 15 Shows how much the participants know about virtual reality technology

Figure 15 Shows the results of View on Virtual Reality Technology. The figure presents the participants' prior knowledge and familiarity with virtual reality (VR) technology in both the experimental group (VR-based training) and the control group (traditional training). The responses indicate different levels of understanding and exposure to VR before participating in the study.

Experimental Group (VR-Based Training)

- The majority of participants (81.57%) indicated that they know something about VR technology but do not have extensive expertise.

- 16.04% stated that they do not know anything about VR, indicating a lack of prior exposure.

- A small percentage (1.71%) reported that they know very much about VR, suggesting a high familiarity with its applications.

- Only 0.68% identified themselves as professionals in VR technology, indicating limited expertise among the participants.

Control Group (Traditional Training)

- Similarly, 79.21% of the control group knew something about VR, demonstrating a comparable level of basic awareness.

- A slightly higher percentage (19.66%) stated that they do not know anything about VR, showing a marginal difference in exposure compared to the experimental group.

- Only 1.12% reported knowing very much about VR, and notably, 0.00% of the control group identified as VR professionals.

Comparison and Interpretation

- Both groups exhibit a general awareness of VR technology, with the majority of participants expressing basic knowledge but lacking professional expertise.

- The experimental group had slightly more individuals who had prior VR exposure, likely due to their interest in participating in VR-based training.

- The control group had a slightly higher percentage of participants unfamiliar with VR (19.66%), which may have influenced their engagement and comfort levels in disaster preparedness training.

These findings suggest that most participants had limited prior experience with VR technology, reinforcing the importance of user-friendly, accessible VR training programs for disaster education.

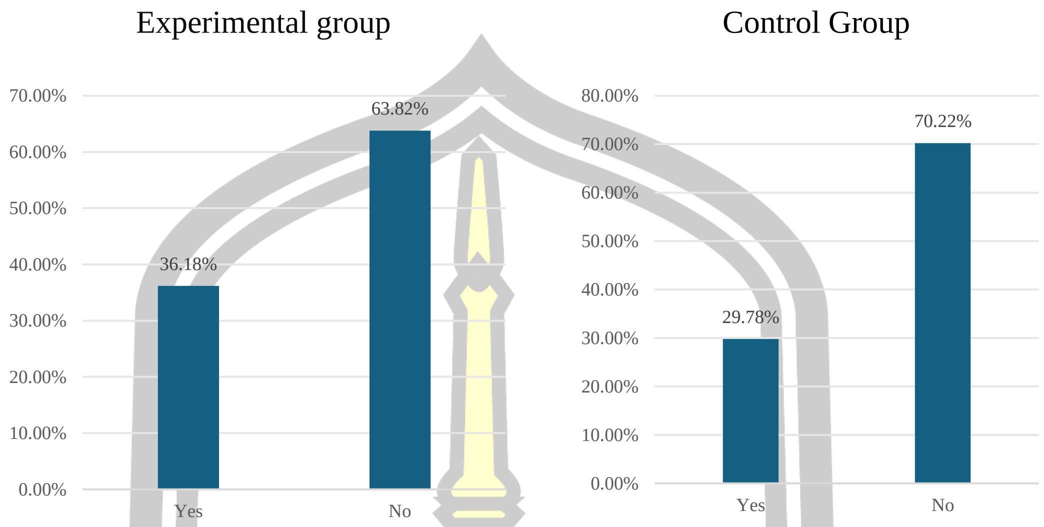

Figure 16 The use of virtual reality devices or experienced virtual reality technology

Figure 16 the use of Virtual Reality Devices or Experience with Virtual Reality Technology, the figure presents the percentage of participants in both the experimental (VR-based training) group and the control (traditional training) group who had previously used or experienced VR technology before participating in this study.

Experimental Group (VR-Based Training)

- 36.18% of participants reported that they had prior experience using VR devices or interacting with VR technology.

- A majority (63.82%) stated that they had never used or experienced VR technology before.

Control Group (Traditional Training)

- A slightly lower percentage (29.78%) had previous experience with VR devices.

- A higher proportion (70.22%) had never interacted with VR technology, indicating a greater unfamiliarity with VR among the control group.

Comparison and Interpretation

- The experimental group had a slightly higher proportion of participants with prior VR experience (36.18%) compared to the control group (29.78%), suggesting that individuals familiar with VR may have been more inclined to participate in VR-based training.

- In both groups, the majority of participants (over 60%) had no prior VR experience, reinforcing the importance of user-friendly VR training design to accommodate beginners.

- The lack of prior VR exposure in the control group (70.22%) may have influenced their perceptions and engagement levels when comparing VR-based learning to traditional training methods.

These findings highlight the need for comprehensive onboarding and guidance for participants unfamiliar with VR technology, ensuring effective and inclusive learning experiences in emergency response training.

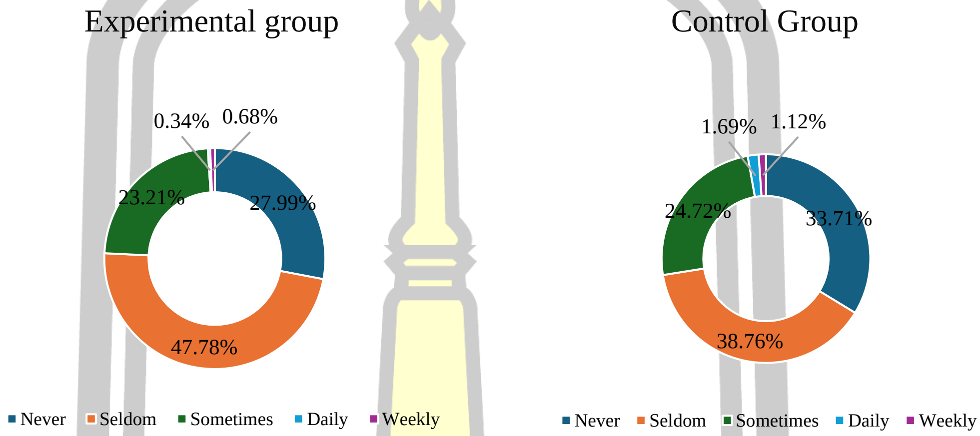

Figure 17 How often for the participants use VR devices

What is your main purpose for using the VR devices?

Table 4 shows that the traditional classroom model remains the most recognized emergency teaching method, with slightly higher awareness in the experimental group than in the control group. MOOC and video-based learning methods were slightly more recognized in the control group, though differences were not statistically significant. Awareness of virtual reality emergency teaching was relatively similar in both groups, suggesting comparable exposure levels. Game entertainment was the most common use of VR, significantly higher in the experimental group compared to the control group (48.05% vs. 33.88%), showing that VR remains predominantly used for entertainment. Education and learning as a VR use case was recognized similarly across groups (27.82% vs. 29.32%). Virtual travel, fitness, and job training showed slightly higher prevalence in the control group, suggesting more diversified VR applications beyond entertainment. Statistically significant differences were found in traditional classroom teaching and game entertainment, emphasizing a contrast in how these methods and VR usage purposes are perceived between groups. (See table 4)

Table 4 Awareness and Usage of Emergency Teaching Methods and Virtual Reality Technology

Emergency Teaching Methods & VR Usage	Experimental Group (n=293)	Control Group (n=178)	Chi-square (X^2)	p-value
Traditional classroom model (offline emergency teaching)	37.57% (201)	32.75% (105)	45.927	0.000***
MOOC, video courses (online teaching mode)	20.75% (111)	23.58% (108)	-	-
Virtual reality emergency teaching	19.44% (104)	17.69% (81)	-	-
Simulated scene and experiential teaching	22.24% (119)	25.98% (119)	-	-
Game entertainment (VR Usage Purpose)	48.05% (209)	33.88% (104)	409.593	0.000***
Education and learning (VR Usage Purpose)	27.82% (121)	29.32% (90)	-	-
Artistic creation (VR Usage Purpose)	6.67% (29)	7.17% (22)	-	-
Virtual travel, fitness, and exercise (VR Usage Purpose)	8.05% (35)	11.73% (36)	-	-
Job training (VR Usage Purpose)	5.06% (22)	12.05% (37)	-	-
Other (VR Usage Purpose)	4.37% (19)	5.86% (18)	-	-

Note: ***, ** and * represent the significance levels of 1%, 5% and 10%, respectively

What emergency teaching methods do you know now

Table 5 indicates that the traditional classroom model remains the most widely recognized emergency teaching method in both groups, though it has a significantly higher popularity rate in the control group (84.27% vs. 68.60%). MOOC and video-based learning have slightly higher awareness in the control group, with a notable increase in popularity rate (60.67% vs. 37.88%). Virtual reality emergency teaching awareness is comparable between groups, though the control group shows a slightly higher popularity rate. Simulated scene and experiential teaching received similar awareness levels in both groups but demonstrated a much higher popularity rate in the control group (66.85% vs. 40.61%), indicating a stronger preference in non-experimental settings. Significant statistical differences were found for the traditional classroom model, reflecting varying levels of endorsement and preference.

Table 5 Awareness and Popularity of Emergency Teaching Methods

Emergency Teaching Methods	Experimental Group (n=293)	Response Ratio (%)	Popularity Rate (%)	Control Group (n=178)	Response Ratio (%)	Popularity Rate (%)	Chi-square (X^2)	p-value
Traditional classroom model (offline emergency teaching)	201	37.57%	68.60%	105	32.75%	84.27%	45.927	0.000***
MOOC, video courses (online teaching mode)	111	20.75%	37.88%	108	23.58%	60.67%	-	-
Virtual reality emergency teaching	104	19.44%	35.49%	81	17.69%	45.51%	-	-
Simulated scene and experiential teaching	119	22.24%	40.61%	119	25.98%	66.85%	-	-

Note: ***, ** and * represent the significance levels of 1%, 5% and 10%, respectively

What do you think is the most important thing of emergency teaching method to the teaching effect?

Table 6 shows that the traditional classroom model remains the most widely recognized emergency teaching method in both groups, with significantly higher popularity in the control group (84.27% vs. 68.60%). MOOC and video-based learning awareness is slightly higher in the control group, with a notable increase in popularity rate (60.67% vs. 37.88%). Virtual reality emergency teaching awareness is comparable, though the control group exhibits a slightly higher popularity rate. Simulated scene and experiential teaching awareness is nearly equal, but its popularity is much greater in the control group (66.85% vs. 40.61%), indicating a stronger preference in non-experimental settings. In teaching effectiveness, accuracy of content and teaching interaction were similarly valued across groups, with higher popularity in the control group. Convenience of learning was significantly more valued in the control group (71.91% vs. 42.32%), with a strong statistical difference (p-value=0.000***), indicating a preference for flexible and accessible teaching formats. Students' real experience was rated more important in the control group (79.21% vs. 49.83%), emphasizing the need for practical engagement. The most significant statistical difference was found for convenience of learning, suggesting that control group participants prioritize accessibility more than those in the experimental group.

Table 6 Importance of Emergency Teaching Methods to Teaching Effect

Teaching Effect Factors	Experimental Group (n=293)	Response Ratio (%)	Popularity Rate (%)	Control Group (n=178)	Response Ratio (%)	Popularity Rate (%)	Chi-square (X^2)	p-value
Accuracy of the content	215	31.48%	73.37%	148	26.20%	83.14%	-	-
Teaching interaction	198	28.99%	67.57%	148	26.20%	83.14%	-	-
Convenience of learning	124	18.16%	42.32%	128	22.66%	71.91%	32.204	0.000***
Students' real experience	146	21.38%	49.83%	141	24.96%	79.21%	-	-

Note: ***, ** and * represent the significance levels of 1%, 5% and 10%, respectively

Have you used virtual reality technology for emergency training in your organization

Usage of Virtual Reality Technology for Emergency Training indentifies that the comparison of Virtual Reality (VR) usage for emergency training between the experimental group and the control group reveals the following key findings: 1) Limited Adoption of VR for Emergency Training, 2) The majority of participants in both groups have not used VR for emergency training 3) 64.85% of the experimental group and 64.61% of the control group indicated that they have not utilized VR in their emergency training programs. 4) This suggests a generally low adoption rate of VR technology in emergency training across both groups. Similar Adoption Rates across groups, the percentage of participants who have used VR for emergency training is nearly identical in both groups: 1) 35.15% in the experimental group, 2) 35.39% in the control group. These results indicate no significant difference between the two groups in terms of VR adoption for training. Implications for VR Integration in Emergency Training. Despite the growing interest in immersive learning, VR is not yet widely implemented in emergency training programs. Potential barriers such as cost, accessibility, technical requirements, and lack of training infrastructure could be limiting factors. Further research is needed to explore the effectiveness of VR-based emergency training and the reasons behind its low adoption rates. (See figure 18)

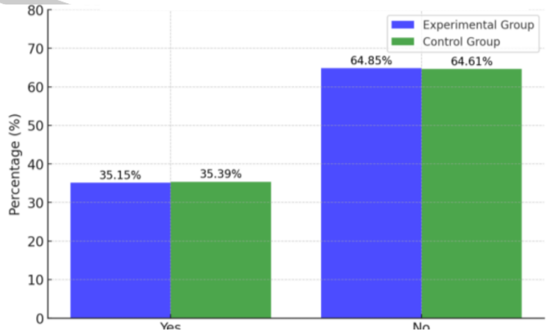

Figure 18 The Comparison of VR Usage for Emergency Training

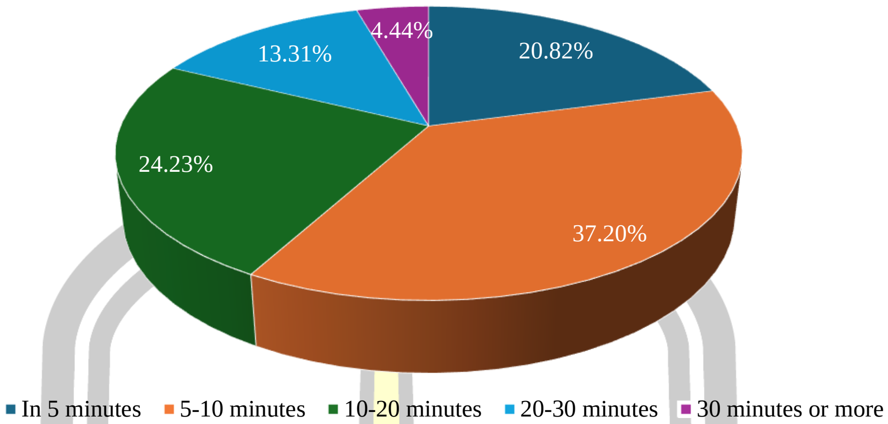

Figure 19 For example, a course of offline fire self-rescue and mutual rescue takes 30 minutes. In the VR teaching mode, how much course time can help you master the methods of escape and self-rescue (experimental group)

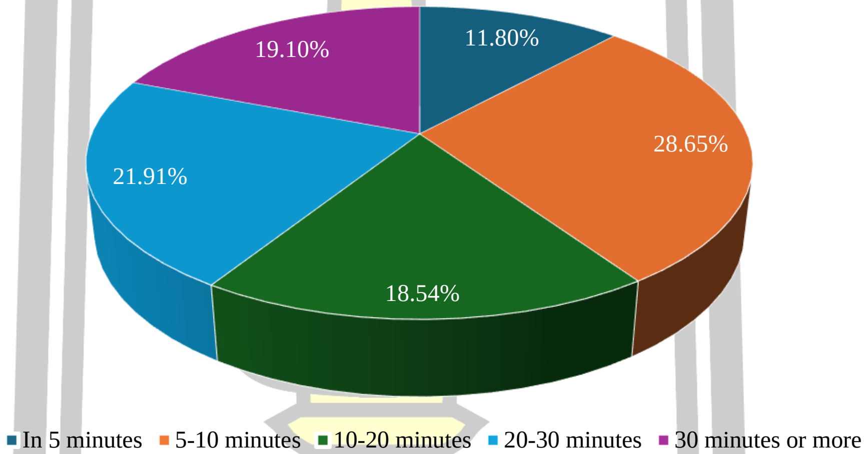

Figure 20 For example, a course of offline fire self-rescue and mutual rescue and flight avoidance takes 30 minutes. Do you think in the VR teaching mode, how much course time can help you master the methods of escape and self-rescue (control group)

As seen in Figure 19, in the experimental group, 20.82% were thought to master within 5 minutes, 37.2% within 5-10 minutes, 24.23% within 10-20 minutes, 13.31% within 20-30 minutes, and only 4.44% took 30 minutes or longer to master. From these data, it is seen that more than half of the students in the experimental group believed that in VR mode, they could master the content of fire escape teaching in 10 minutes, which shows the potential of VR technology to improve learning efficiency. In Figure 20, 11.8% of trainees were considered to be available within 5 minutes, 28.65% within 5-10 minutes, 18.54% within 10-20 minutes, 21.91% within 20-30 minutes, and 19.1% considered within 30 minutes or more. Compared with the experimental group, a relatively high percentage of participants in the control group thought that it would take a longer time (more than 20 minutes) to master the lesson, suggesting that the control group may have a lower expectation of learning efficiency in the VR mode. By comparing the responses of the experimental group with those of the control group, we can conclude that the experimental group generally believed that they could master the fire escape content in a shorter time in the VR mode, while the control group expected that it would take a longer time. This may be due to the fact that the experimental group has already experienced the effect of VR teaching and has a more intuitive understanding of and confidence in it. The data from the experimental group show that VR teaching has significant advantages in reducing learning time and improving learning efficiency. This may be related to the fact that VR technology can provide a more immersive and interactive learning environment, which can help learners master knowledge and skills more quickly. The higher proportion of the control group who thought it would take 30 minutes or more may reflect their unfamiliarity or uncertainty with VR teaching and their inertia about the time required in traditional teaching methods.

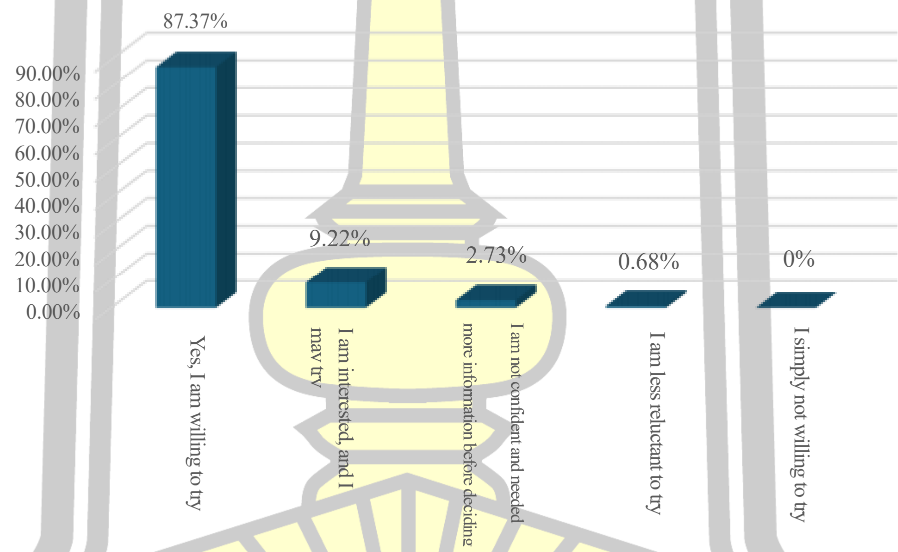

Figure 21 Are you willing to try the VR emergency teaching (control group)

As can be seen from Figure 21, in the experimental group, the majority of students indicated they were willing to try, 87.37%, indicating that the students in the experimental group have a very positive attitude towards VR emergency teaching. Another 9.22 percent said, “I am interested, and I may try”, which also showed minor interest. Only 2.73% said they were not confident and needed more information before deciding, while a small group (0.68%) was not willing to participate in the control group. 178 people participated in answering the same question. Compared with the experimental group, although the proportion of students saying “yes, I am willing to try” is still high, it has dropped to 70.79%, lower than the 87.37% in the experimental group. The percentage of interested students who were willing to try was 17.42%, slightly lower than the actual percentage of 9.22% in the experimental group. At the same time, the percentage of students who were unsure and required more information was 9.55%, higher than that of the experimental group, while the percentage of students saying they were reluctant to try was 2.25%, although not high, but slightly higher than that of the experimental group. From a percentage perspective, the proportion of students in the experimental group who were willing to try VR emergency teaching, including “very willing to try” and “may try it”, was significantly higher than that in the control group. Meanwhile, the proportion of students in the experimental group who were uncertain and less willing to try was lower than that in the control group. These differences indicate that students in the experimental group are generally more receptive and interested in VR emergency teaching than those in the control group, perhaps because the experimental group has a deeper understanding of VR technology or emergency teaching or is more open to new technologies and teaching methods.

The following questions are slightly different between the experimental group and the control group, mainly about the experimental group’s understanding of virtual reality in the field of emergency education after using VR equipment; but the control group still did not have VR experience and answered with their own understanding and cognition.

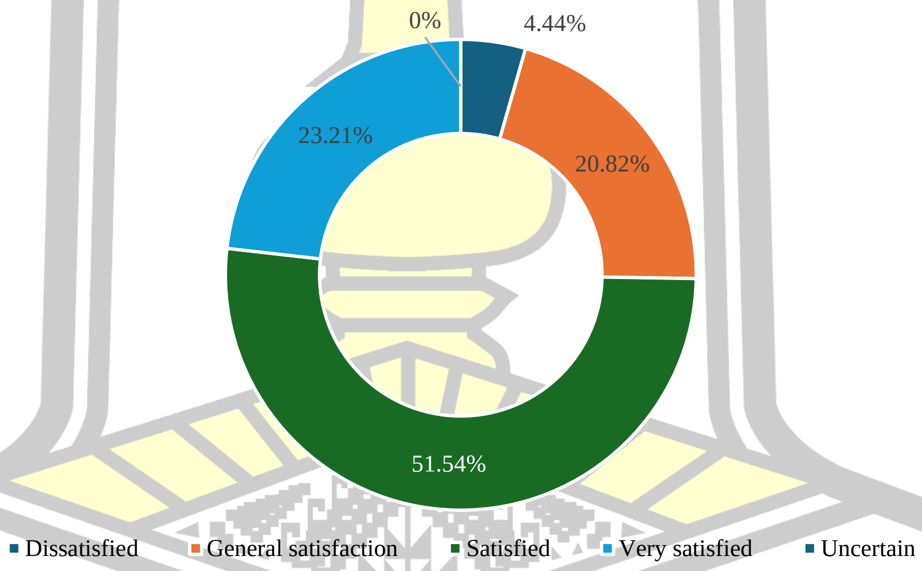

Figure 22 Are you satisfied with the current virtual reality technology experience (experimental group)

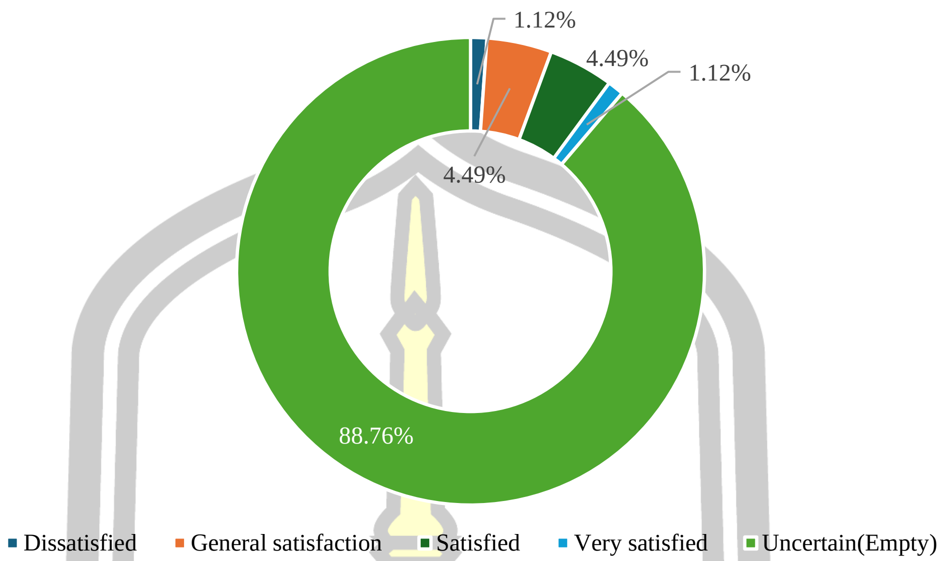

Figure 23 Are you satisfied with the current VR technology experience (control group)

From Figure 22, in the experimental group, the "satisfied" students occupied the highest percentage of 51.54%. It shows that more than half of the students have positive reviews of the current VR technology experience. This was followed by a "very satisfied" ratio of 23.21 percent, indicating that many students are very satisfied with the experience of virtual reality technology. In addition, 20.82% of the students expressed "general satisfaction", although the satisfaction was not as high as the first two options, it also showed that they had a certain recognition of virtual reality technology. Only 4.44 percent of the students were "dissatisfied", indicating that most of the students were satisfied with the experience of virtual reality technology. It is worth noting that no trainees chose the option of "uncertain". In Figure 23 of the control group, the proportion of students who chose "(blank)", that is, did not give a clear answer, was as high as 88.76%. Hesitation, uncertainty, or a lack of understanding of VR technology were the main culprits when the answers given to questions led to an unclear evaluation. Among the clear answers, the percentages of "very satisfied" and "satisfied" were very low, only 1.12% and 4.49%, respectively, far lower than the percentage in the experimental group. Meanwhile, the percentage of students expressing "general satisfaction" and "dissatisfaction" was also relatively low, at 4.49 percent and 1.12 percent, respectively. From a percentage perspective, the percentage of students in the experimental group with positive reviews (including "satisfied", "very satisfied" and "generally satisfied") was significantly higher than that in the control group. The total proportion of positive evaluations in the experimental group was 95.57%, compared with only 11.12% in the control group (if students who did not give clear answers were not considered). In particular, the percentages of "satisfied" and "very satisfied" were 47.05% and 22.09%, respectively higher than in the control group.

The differences suggested that students in the experimental group were generally more satisfied with the experience of VR, probably because they gained better experience in actual use, or their expectations of VR were more matched with the actual situation. Many answers from students in the control group were not reflected clearly. which also showed their lack of understanding of virtual reality technology or their lack of sufficient opportunities for experience.

Table 7 What aspects do you think require improvement or enhancement in virtual reality technology (experimental group)

Multiple topic topics	N (count)	Response ratio (%)	Popularity rate (%)	X²	p-value
Image quality, clarity	159	30.994%	54.266%		
Equipment comfort	108	21.053%	36.86%		
Mobility and operability	84	16.374%	28.669%		
Price and cost	53	10.331%	18.089%	197.411	0.000***
Photo delay, dizziness	50	9.747%	17.065%		
User interface and Interactive experience	52	10.136%	17.747%		
Else	7	1.365%	2.389%		
Amount to	513	100%	175.085%		

Note: ***, ** and * represent the significance levels of 1%, 5% and 10%, respectively

Table 8 What aspects do you think requires improvement or enhancement in virtual reality technology (control group)

Multiple topic topics	N (count)	Response ratio (%)	Popularity rate (%)	X²	p-value
Image quality, clarity	13	20.312%	7.303%		
Equipment comfort	14	21.875%	7.865%		
Mobility and operability	10	15.625%	5.618%	11.906	0.064*
Price and cost	8	12.5%	4.494%		
Photo delay, dizziness	10	15.625%	5.618%		
User	8	12.5%	4.494%		

Multiple topic topics	N (count)	Response ratio (%)	Popularity rate (%)	X²	p-value
interface and Interactive experience					
Else	1	1.562%	0.562%		
Amount to	64	100%	35.955%		

Note: ***, ** and * represent the significance levels of 1%, 5% and 10%, respectively

According to Table 7, in the experimental group, the response rate of the various indicators showed significant differences in the aspects that needed improvement or enhancement in VR technology. Among them, the response rate of "image quality, clarity" was the highest, reaching 30.994%, showing that this problem is the focus of the members of the experimental group. This was followed by a "device comfort" response rate of 21.053% and "mobility and operability" response rate of 16.374%, while "price and cost", "photo delay, dizziness," and "user interface and interactive experience" were relatively low, but still received some attention. In addition, the "other" option had the lowest response rate, with only 1.365%. The significance level used in this study was 1% (***), the chi-square value was 197.411, and p-value=0.000 rejected the null hypothesis at the 1% significance level. In Table 10 of the control group, the response rate of the indicators was generally low and relatively more balanced. Similarly, "image quality, clarity" had the highest response rate, but only 20.312%, lower than that in the experimental group. Other response rates such as "device comfort," "Mobility and operability," "price and cost," "photo delay, dizziness," and "user interface and interactive experience" fluctuated between 12.5% and 21.875%, with little difference. The "other" option also had the lowest response rate of 1.562%. The response rate of the experimental group and the control group in the virtual reality technology needs improvement. We found that the experimental group paid significantly more attention to "image quality and clarity" than the control group, and the response rate reached 30.994%, while the control group was only 20.312%. Simultaneously, the experimental group showed greater emphasis than the control group on aspects such as "device comfort," "mobility and operability," "price and cost," "photo delay and dizziness," and "user interface and interactive experience," although the degree of difference varied. These results indicate that members of the experimental group have higher expectations and requirements for the overall performance and user experience of VR technology, while the control group may show higher attention in certain aspects. Overall, the two groups differ in the need for VR improvement, which may be related to their experience with their use, demand preferences or technical expectations have.

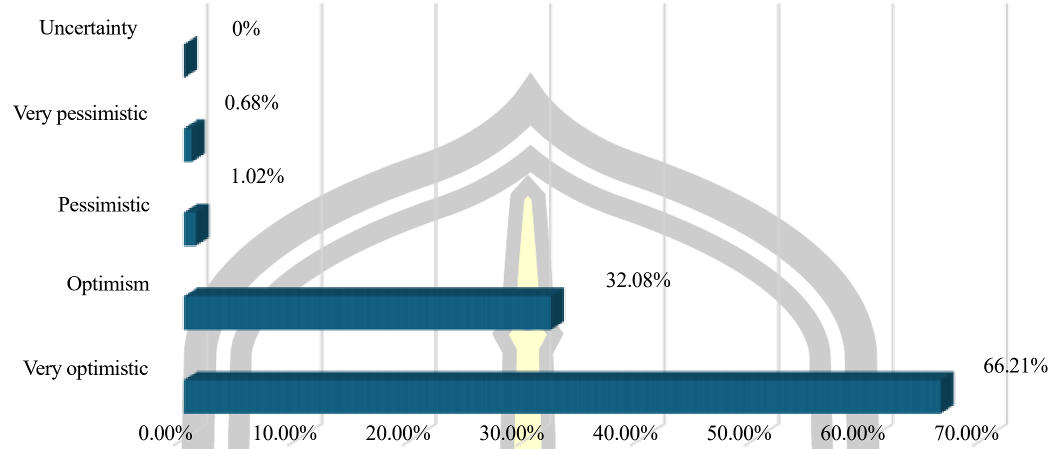

Figure 24 What do you think of the development prospect of virtual reality technology in the next few years

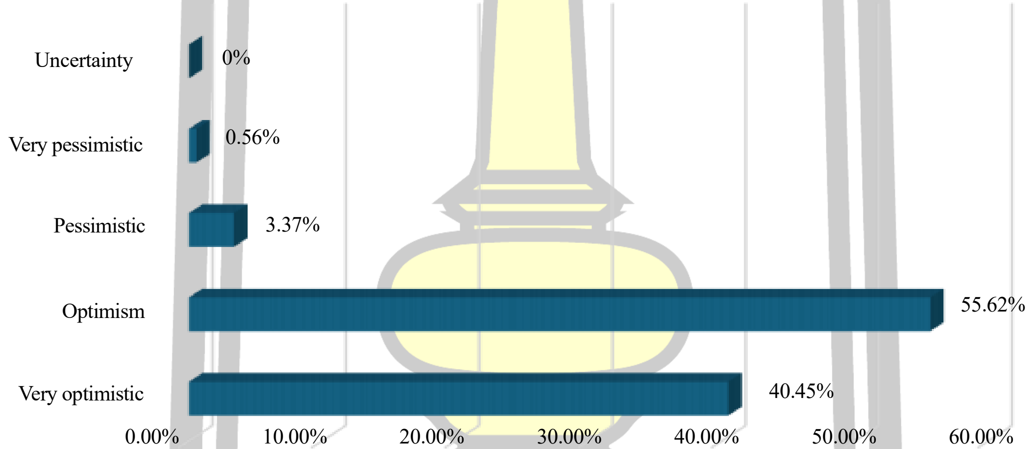

Figure 25 What do you think of the future of VR technology in the next few years

As seen in Figure 24, "very optimistic" students in the experimental group reached 66.21%, showing that more than two-thirds of the students held very positive views on the development prospects of VR technology in the next few years. This was followed by "optimism", at 32.08%, indicating that a significant number of students held optimistic views on the future development of VR technology. In contrast, the percentages of "pessimistic" and "very pessimistic" students were low, at 1.02% and 0.68%, respectively, indicating that a vast majority of students were positive about the future development of VR technology. No trainee opted for "uncertainty", indicating that everyone in the survey had a clear view of the future development of VR. In the control group, 16,178 people participated in answering the same questions. Compared with the experimental group, although the percentage of optimistic students were still the majority in the control group, the percentage decreased to 55.62%. Meanwhile, the percentage of "very optimistic" students decreased to 40.45 percent, but still higher than the “pessimistic” and “very pessimistic” ratios. In the control group, the percentages of ”pessisimistic” and “very pessisimistic” students were 3.37% and 0.56%, respectively. Although they were not high, they were still high in relative to the experimental group. Similarly, no trainee chose the option of "uncertain". From a percentage perspective, the percentage of students in the experimental group who held very optimistic views about the future of VR technology was significantly higher than that in the control group, or 25.76 percentage points higher. It shows that the experimental group has more positive views on the future of VR technology. At the same time, although the percentage of students who are optimistic in the experimental group was lower than that in the control group, the gap between the two was minimal, and the percentage was rather high in the experimental group. It is important to note that the percentage of pessimistic and very pessimistic students expressing their views in the experimental group was significantly lower than in the control group. Specifically, there was a decrease of 2.35 percentage points for those labeled as "pessimistic" and a decrease of 0.12 percentage points for those categorized as "very pessimistic." The differences indicate that students in the experimental group are generally more likely to use virtual reality in the future. They have a more optimistic outlook on the development prospects of surgery. In contrast, while most students in the control group are also optimistic, they tend to be more cautious, and a notable percentage of them hold a pessimistic view.

Table 9 What advantages do you think of virtual reality emergency teaching compared with other methods (experimental group)

Multiple topic topics	**N (count)**	**Response ratio (%)**	**popularity rate (%)**	**X^2**	**p-value**
Authentic and immersive experience	258	35.488%	88.055%		
Real-time feedback and evaluation	128	17.607%	43.686%		
Repeated teaching	126	17.331%	43.003%		
Personalized learning	89	12.242%	30.375%	376.16	0.000***
Strengthen teamwork	60	8.253%	20.478%		
Reduce training costs	65	8.941%	22.184%		
Else	1	0.138%	0.341%		
Amount to	727	100%	248.123%		

Note: ***, ** and * represent the significance levels of 1%, 5% and 10%, respectively

Table 10 What do you think are the advantages of VR emergency teaching compared with other methods (control group)

Multiple topic topics	N (count)	Response ratio (%)	Popularity rate (%)	X^2	p-value
Authentic and immersive experience	19	27.143%	10.674%	20.8	0.002***
Real-time feedback and evaluation	13	18.571%	7.303%		
Repeated teaching	13	18.571%	7.303%		
Personalized learning	9	12.857%	5.056%		
Strengthen teamwork	8	11.429%	4.494%		
Reduce training costs	8	11.429%	4.494%		
Else	0	0%	0%		
Amount to	70	100%	39.326%		

Note: ***, ** and * represent the significance levels of 1%, 5% and 10%, respectively

According to Table 9, respondents in the experimental group most commonly identified the program as providing an "authentic and immersive experience," which received a response rate of 35.49%. It indicated that this particular benefit had garnered considerable attention and recognition among participants. Following this, the advantages of "real-time feedback and assessment," "repeated teaching," and "personalized learning" were positively acknowledged too, with response rates ranging from 12% to 18%. This suggested a significant number of respondents placed great value on these benefits as well. In contrast, the response rates of "strengthening teamwork" and "reducing training costs" were lower, at 8.253% and 8.941%, respectively. In addition, very few respondents chose the "other" option. The significance level used in this study was 1% (***) with a chi-squared value of 376.16 and p-value = 0.000 rejected at 1% significance.

The adiabatic hypothesis. In the control group Table 10, the respondents' views on the advantages of VR emergency teaching were different from those of the experimental group. Although "authenticity and immersive experience" was still the most recognized advantage, its response rate was only 27.143%, a significant decrease compared to the experimental group. At the same time, the response rates of the advantages of "real-time feedback and evaluation", "repeated teaching", "personalized learning", "strengthening teamwork" and "reducing training costs" were all similar, all between 11% and 19%. No respondent chose the "other" option in the control group. The chi-square value was 20.8, and p-value = 0.002 rejected the null hypothesis at the 1% significance level. In the experimental group, the response rate of the advantage of "authenticity and immersive experience" was much higher than that of the control group, indicating that the respondents in the experimental group were more attentive to virtual reality emergency teaching. For the advantages of "real-time feedback and evaluation", "repeated teaching" and "personalized learning", the response rate of the experimental group was also higher than that of the control group, but the gap was relatively small. "Strengthening teamwork" and "reducing training costs" had lower response rates in both groups, but the experimental group had slightly more recognition in both areas than the control group. In the control group, no respondents chose the "other" option, while only a few people in the experimental group chose, which may indicate that the advantages of virtual reality emergency teaching are relatively clear and concentrated in the respondents' mind. In conclusion, there were some differences between the experimental group and the control groups in the recognition of virtual reality emergency teaching advantages, but "authenticity and immersive experience" as the most prominent advantages were widely recognized in both groups.

Table 11 What do you think is the most suitable scenario for VR emergency teaching (experimental group)

Multiple topic topics	N (count)	Response ratio (%)	Popularity rate (%)	X²	p-value
Enterprise safety training	222	21.224%	75.768%		
School emergency drill	203	19.407%	69.283%		
Family emergency education	171	16.348%	58.362%		
Safety teaching in public places	160	15.296%	54.608%	198.822	0.000***
Fire escape	147	14.054%	50.171%		
Natural disasters such as earthquakes and floods	138	13.193%	47.099%		
Else	5	0.478%	1.706%		
Amount to	1046	100%	356.997%		

Note: ***, ** and * represent the significance levels of 1%, 5% and 10%, respectively

Table 12 What do you think is the most suitable scenario for VR emergency teaching (control group)

Multiple topic topics	N (count)	Response ratio (%)	Popularity rate (%)	X²	p-value
Enterprise safety training	13	14.773%	7.303%		
School emergency drill	16	18.182%	8.989%		
Family emergency education	15	17.045%	8.427%		
Safety teaching in public places	14	15.909%	7.865%	15.25	0.018***
Fire escape	16	18.182%	8.989%		
Natural disasters such as earthquakes and floods	14	15.909%	7.865%		
Else	0	0%	0%		
Amount to	88	100%	49.438%		

Note: ***, ** and * represent the significance levels of 1%, 5% and 10%, respectively

It can be seen from Table 11 that in the experimental group, the most selected scenario was "enterprise safety training", with a response rate of 21.224%, showing that this scenario received wide attention and recognition in the experimental group. This was followed by "school emergency drills", "family emergency education", "public safety education" and "fire escape", with response rates between 14% and 20%, indicating that these scenarios are also considered as a suitable environment for VR emergency teaching by a significant number of respondents. In contrast, the response rate of "natural disasters such as earthquakes and floods" was slightly lower, at 13.193%. In addition, only a few respondents chose the "other" option. The significance level used in this study was 1% (***), with a chi-square value of 198.822, and p-value = 0.000 rejected the null hypothesis at the 1% significance level. In the control group Table 12, the respondents viewed the most suitable scenario for VR emergency teaching differently from the experimental group. Although the response rate of "enterprise safety training", "school emergency drill", "fire escape" and other scenarios is relatively close, all are between 14% and 18%. At the same time, the response rate and penetration rate of "family emergency education", "safety education in public places" and "earthquake, flood and other natural disasters" are also relatively close, and the overall response rate is lower than that of the experimental group. It is noteworthy that no respondent chose the "other" option in the control group. The chi-square value was 15.25, and p-value = 0.018 rejected the null hypothesis at the 1% significance level. In the experimental group, the response rate of the scenario of "enterprise safety training" was much higher than that of the experimental group, indicating that the respondents in the experimental group paid more attention to the application of VR emergency teaching in enterprise safety training. For the scenarios of "school emergency drill", "family emergency education", "safety education in public places" and "fire escape", the response rate of the experimental group was also higher than that of the control group, but the gap was relatively small. This shows that the respondents in the experimental group also have a more positive attitude towards the application of VR emergency teaching in these scenarios. The response rate to "natural disasters such as earthquakes and floods" was low in both groups, but the experimental group was slightly more recognized in this respect than the control group. No respondents in the control group chose the "other" option, while only a few people in the experimental group selected it, which may indicate that the suitable scenario of VR emergency teaching is relatively clear and concentrated in the respondents. In conclusion, there are some differences between the experimental group and the control group in the scenarios most suitable for VR emergency teaching, but "enterprise safety training" as the most prominent scenario has received relatively high recognition in both groups. At the same time, the respondents of the two groups also showed some similarities in other scenes, but the overall response rate of the experimental group was higher than that of the control

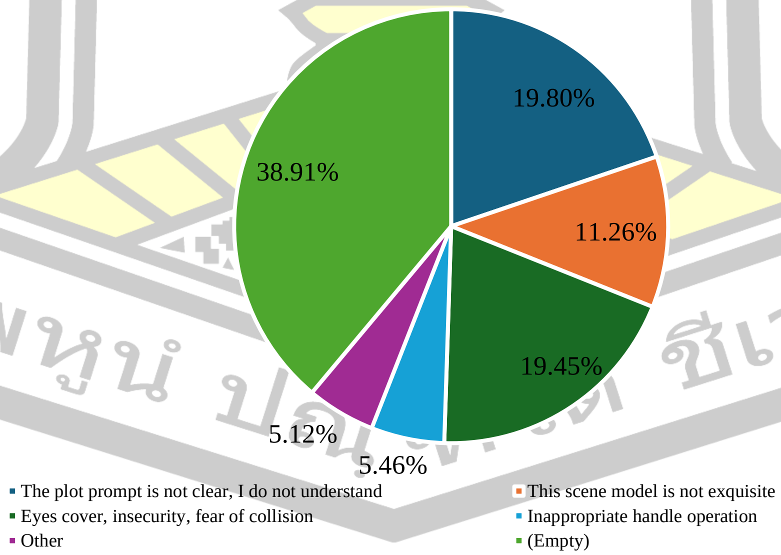

Figure 26 What is the uncomfortable experience of training with virtual reality (experimental group)

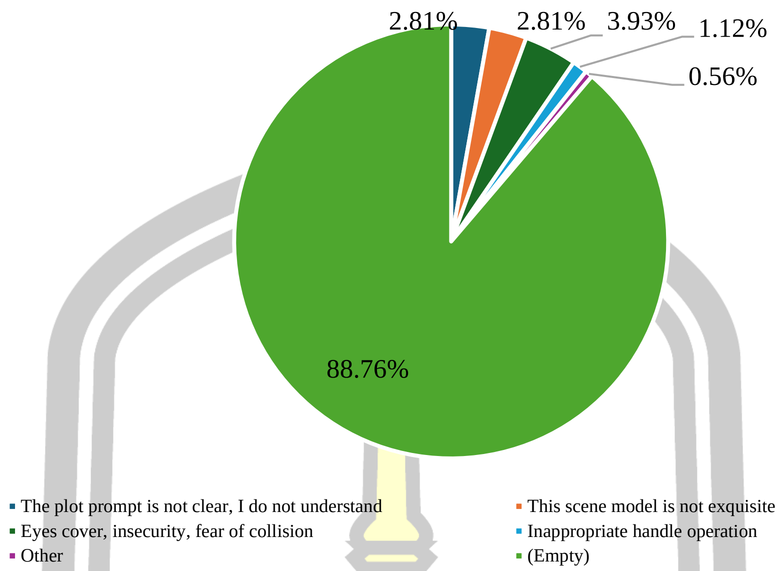

Figure 27 Why is it uncomfortable to train with virtual reality (Control group)

From Figure 26, in the experimental group, " What is the uncomfortable experience of training using virtual reality?", Choosing" the plot prompt is not clear, I do not understand " was the highest proportion, at 19.8%, indicating that nearly one-fifth of the experimental group members encountered difficulties in understanding the plot when training with virtual reality. This was followed by "eyes cover, insecurity, fear of collision", which was 19.45%, indicating that a significant number of the experimental group members were upset because of limited vision. The proportion of choosing "this scene model is not exquisite" was 11.26%, indicating that the delicacy of the scene model is also the reason why some of the experimental group members felt uncomfortable. However, the "inappropriate handle operation" and "other" options were only 5.46% and 5.12% of the experimental group members were selected, respectively, with a low relative proportion. Notably, 38.91% of the experimental group members chose the "(empty)" option, which may mean that they did not experience obvious uncomfortable experiences when training with virtual reality, or they chose not to answer this question. In the control group, Figure 27, when compared to the experimental group, The proportion of selected individual options was generally lower in the control group. Among them, the proportion of "plot prompt is not clear, I don’t understand", "this scene model is not delicate" and "eyes covered, insecure, afraid of collision" were 2.81%, 2.81% and 3.93%, respectively, far lower than the proportion in the experimental group. At the same time, the "inappropriate handle operation" and "other" options were only 1.12% and 0.56% of the control group members, respectively. It is worth noting that up to 88.76% of the control members chose the "(empty)" option, which was significantly higher than that of the experimental group, implying that they had not involved in the relevant experience and therefore did not know whether VR was comfortable. From a percentage perspective, the proportion of each option in the experimental group was generally higher than that in the control group. Especially "the plot tip is not clear, I don't understand" and "eyes cover, insecurity, afraid of collision" the two options, the proportion of the experimental group and 15.52%, indicating that the experimental group members when using virtual reality training uncomfortable experience is relatively more significant. At the same time, the proportion of choosing the "(empty)" option in the experimental group was much lower than that in the control group, 49.85 percentage points lower, which further indicates that the problems or uncomfortable experiences encountered by the experimental group members when training with virtual reality were more common and significant. The differences suggest that members of the experimental group may face more challenges and discomfort in training with more attention and improvement when using VR.

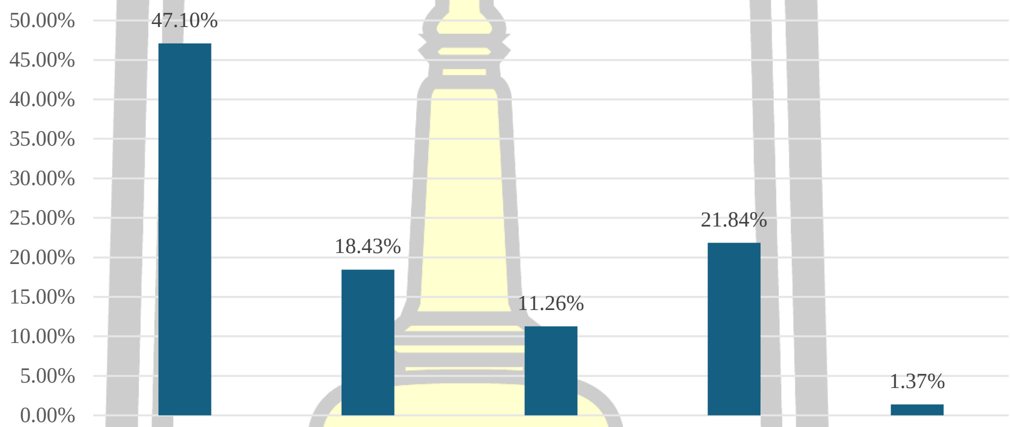

Figure 28 What do you consider the benefits of VR in emergencies and safety training (experimental group)

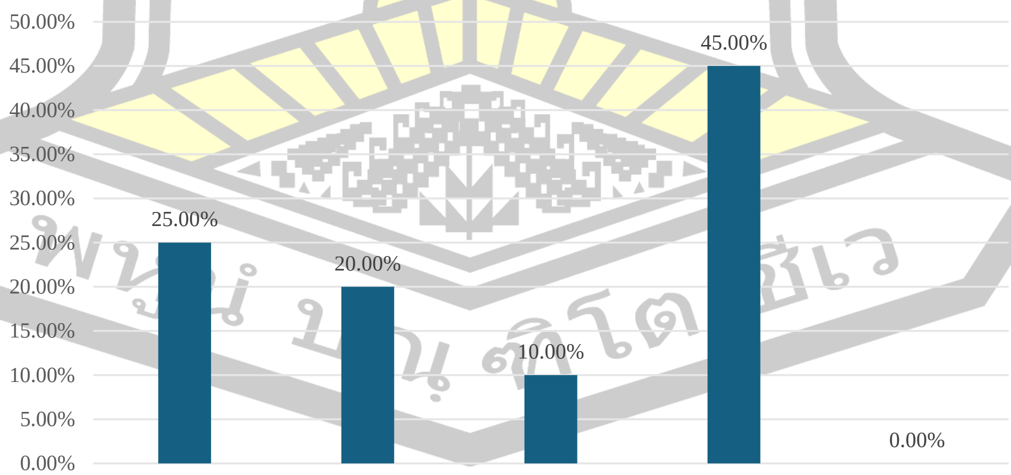

Figure 29 What do you consider the benefits of VR in emergency and safety training (control group)

As seen from Figure 28, in the experimental group, the percentage of selecting "authenticity of image and sound effects" was the highest, with 47.1%, indicating that more than half of the experimental group members believed that the biggest benefit of virtual reality technology in emergency and safety training lies in the authenticity of their images and sound effects. This was followed by "immersive, highly simulated and diverse training scenarios" with 21.84%, indicating that nearly a fifth of the experimental group members value the immersive training environment provided by VR technology. The proportion of selecting "portability and ease of use of the device" and "interaction and operation experience" were 18.43% and 11.26%, respectively, indicating that the portability, ease and ease of use of the device and the interaction and operation experience gained through VR technology were also the benefits considered by some members of the experimental group. The "other" option is only 1.37% of the experimental group members, a low relative proportion. In the control group Figure 29, 20 people participated in answering the same question. The proportion of individual options varied in the control group compared to the experimental group. Among them, "immersive, highly simulated and diversified training scenarios" had the highest proportion of 45%, indicating that more than half of the members of the control group believed that the biggest benefit of VR technology in emergency and safety training is the immersive training environment it provides. This was followed by "authenticity of images and sound effects", 25%, much lower than the proportion in the experimental group. The rates of "portability and ease of use of the device" and "interaction and operation experience" were 20% and 10%, respectively, which were also relatively low. Notably, no control group members chose the other option. From the percentage point of view, the proportion of "authenticity of images and sound effects" in the experimental group is much higher than that in the control group, 22.1 percentage points higher, indicating that the experimental group members pay more attention to the authenticity of virtual reality technology in terms of images and sound effects. In the control group, the proportion of "immersive, highly simulated and diversified training scenarios" was much higher than that of the experimental group, with 23.16 percentage points higher, indicating that the members of the control group paid more attention to the immersive training environment provided by virtual reality technology. In addition, the proportion of the experimental group choosing "portability and ease of use of the device" was also higher than that of the control group, which was 8.43 hundred higher points, indicating that the experimental group members have some concern about the portability and ease of use of the device. While the "interaction and operational experience" option had relative proportions in both groups.

However, the experimental group was still 1.26 percentage points higher than the control group. These differences indicate that the experimental and control group members have some differences in viewing the benefits of VR in emergency and safety training, and that further research and analysis on the needs and preferences of different groups are needed.

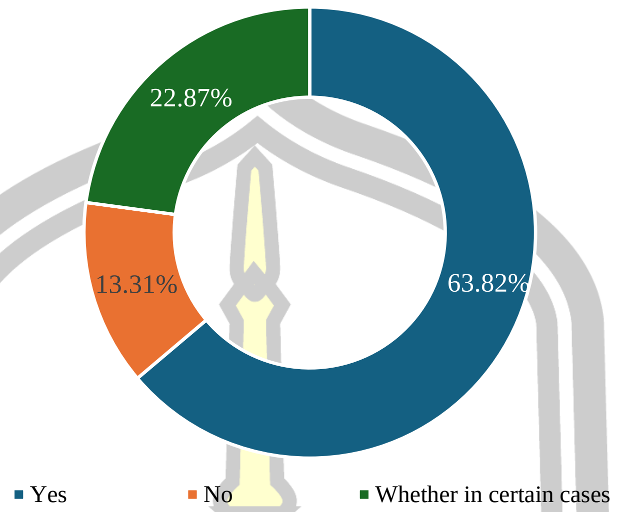

Figure 30 Do you think that virtual reality technology can replace the traditional training methods in emergency training (experimental group)

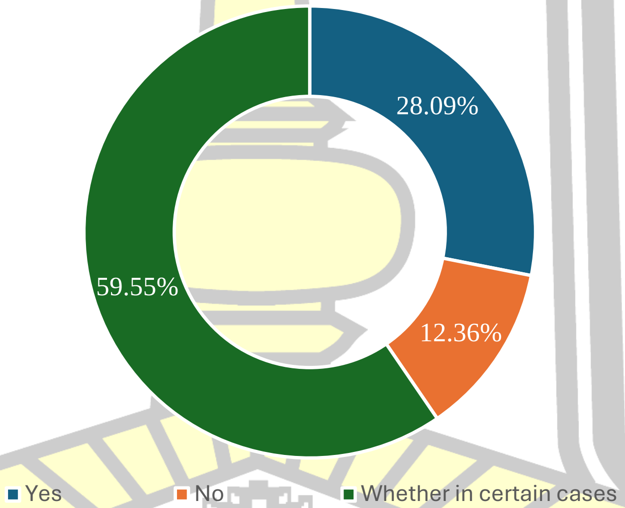

Figure 31 Do you think that virtual reality technology can replace the traditional training methods in emergency training (control group)

From Figure Figure 30, in the experimental group, the proportion of selecting "yes" was the highest, at 63.82%, indicating that more than half of the experimental group members believe that virtual reality technology has the potential to completely replace the traditional training methods in emergency training. Next was the proportion of selected "in some cases", 22.87%, indicating that a considerable number of experimental group members believe that virtual reality technology can be used as a supplement or alternative to traditional training methods in a specific context. However, the proportion of "no" was relatively low, with only 13.31%, indicating that only a few members of the experimental group believed that VR technology could not completely replace traditional training methods. In the Figure Figure 31 control group, 178 people participated in answering the same questions. There were significant differences in the proportion of individual options selected in the control group compared to the experimental group. Among them, the proportion of selection "in some cases" was the highest, 59.55%, much higher than the proportion in the experimental group, indicating that more than half of the members of the control group believed that virtual reality technology could be mainly effective in specific situations, rather than completely replacing traditional training methods. The proportion of "yes" was 28.09%, which was much lower than the ratio in the experimental group. For example, which shows that the control group members are relatively conservative in the view that the virtual reality technology completely replaces the traditional training methods. However, the proportion of "no" was relatively close in the two groups, with 12.36% in the control group, slightly lower than 13.31% in the experimental group. From the percentage perspective, the proportion of "yes" in the experimental group was much higher than that in the control group, 35. 73 percentage points higher, indicating that the experimental group members had more optimistic and positive views of virtual reality technology replacing traditional training methods. In the control group, the proportion of choosing "in some cases" was much higher than that in the experimental group, 36.68 percentage points higher, indicating that the control group members prefer to think that virtual reality technology can mainly play a role in specific situations, rather than fully replacing the traditional training methods. These differences indicate that the experimental group members (actually involved in VR experience) and the control group members (not involved or even exposed to VR) differ significantly from the alternative role of VR in emergency training, which is likely to be affected by their different backgrounds, experiences or perceptions. As the control group may lack experience with VR, they have limited knowledge of VR techniques and therefore, may be uncertain or ignorant about the applicability of VR in emergency training. In contrast, the experimental group may have a more direct and in-depth understanding of the effects of VR technology through hands-on experience. Therefore, in the promotion and application of virtual reality technology, it is necessary to fully consider the needs and views of different groups, especially for those groups who have not yet been exposed to VR technology, and develop targeted strategies and measures to ensure the effective popularization and application of the technology.

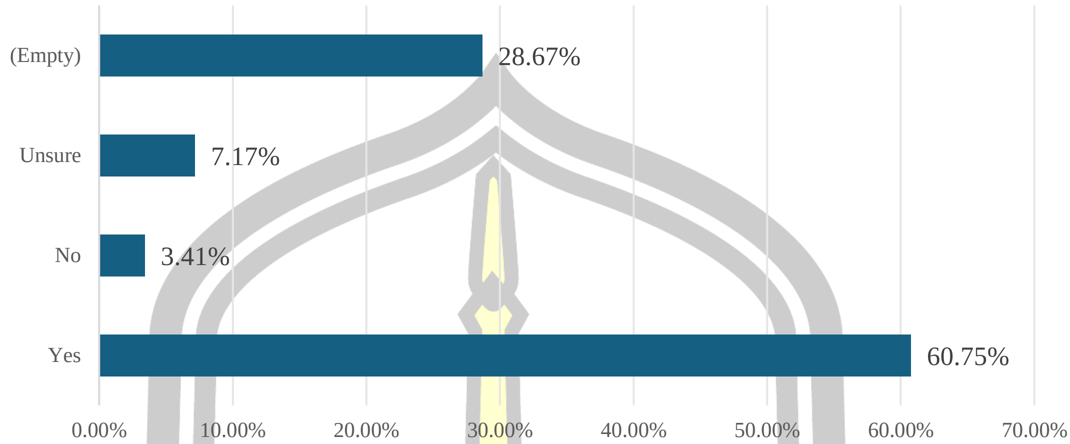

Figure 32 Do you think VR technology can improve your response ability and response speed to emergency training (experimental group)

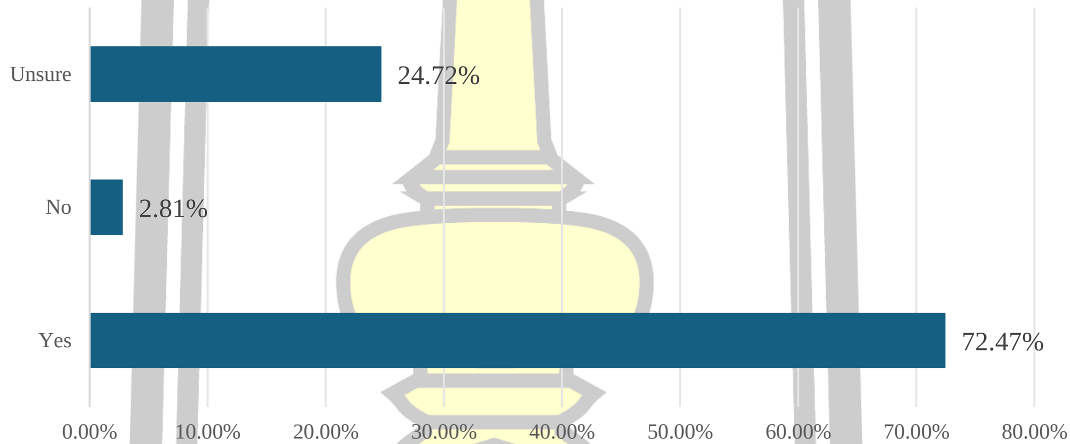

Figure 33 Do you think VR technology can improve your response ability and response speed to emergency training (control group)

As seen from Figure 32, the percentage of selecting "yes" was the highest in the experimental group, reaching 60.75%, showing that most experimental group members believed that VR technology helps to improve their response ability and response speed in emergency training. The choice of "no" was very low, at only 3.41%, indicating that few members of the experimental group thought that the VR technology was not helpful. At the same time, 7.17 percent of the experimental group members said "uncertain", they are wait and see about the effect of VR technology. It is worth noting that 28.67% of the experimental group members did not answer this question, possibly indicating that they have no clear views on the issue or are unwilling to express their opinions. In the control group, Figure Figure 33, Compared with the experimental group, the proportion of choosing "yes" was higher in the control group, reaching 72.47%, showing that the vast majority of members in the control group held a positive attitude towards the role of VR technology in improving the response ability and response speed of emergency training. This result may reflect that although the control group did not actually experienced VR teaching (and therefore their knowledge may be based on indirect information or preset expectations), they had high expectations for participating in VR teaching, believing that the technique may have a positive impact. However, because the experimental group actually experienced VR technology, their views may be more specific and based on actual feelings. Therefore, in the promotion and application of virtual reality technology, not only to consider those positive expectations of VR not experience (as the control group), also need to through practical experience to enhance their understanding and confidence, at the same time for experience (experiment) feedback to optimize technology application, in order to meet the needs of different groups and expectations. The proportion of "no" was still very low, at 2.81%, similar to the experimental group. However, the proportion of "uncertain" being selected in the control group was higher, 24.72%, indicating that a part of the control group members had doubts about or have not formed a clear view on the effect of VR technique. From a percentage perspective, there were significant differences in the proportion between the experimental and control groups. The proportion of "yes" in the control group was 11.72 percentage points higher than the experimental group, indicating that more members of the control group believed that VR technology could significantly improve the response ability and response speed of emergency training. Instead, the proportion of choosing "uncertain" in the experimental group was 7.55 percentage points higher than that in the control group, indicating that more members of the experimental group were wait-and-see or uncertain about the effect of VR technology. In addition, the proportion of unanswered questions in the experimental group was also high, which may further affect the overall view of the experimental group on the effect of VR technology. These differences may reflect differences in the understanding and acceptance of the application of VR technology in emergency training, and require more in-depth research and communication on the needs and doubts of different groups.

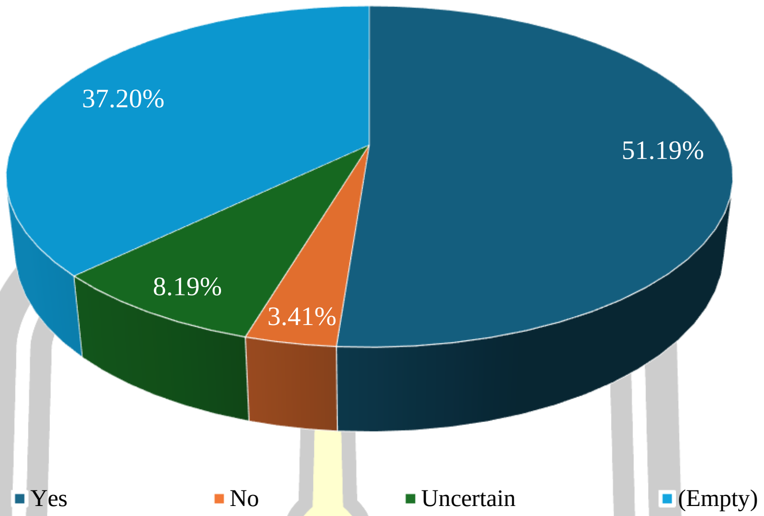

Figure 34 Do you think it can help you feel calmer in the face of real disaster by adapting to real VR disaster scenarios (experimental group)

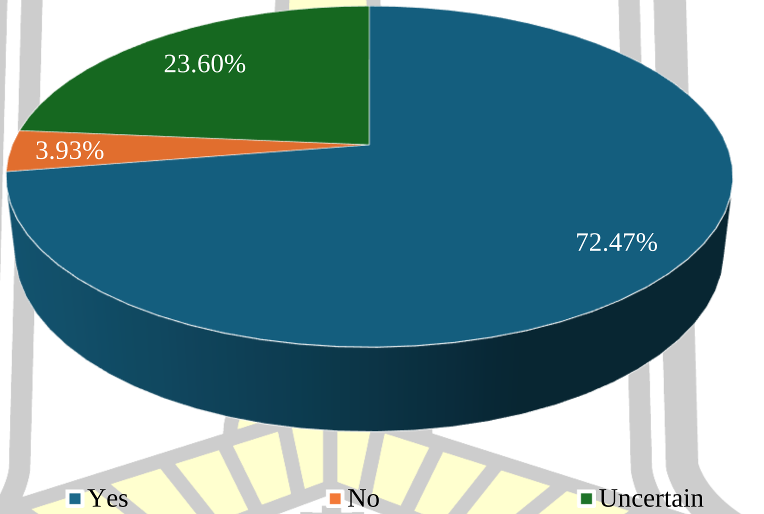

Figure 35 Do you think it can help you feel calmer in the face of the real disaster by adapting to the real VR disaster scenario (control group)

From Figure 34, in the experimental group, choosing "yes" accounted for 51.19% of the total number, showing that more than half of the participants believed that the adaptation of VR disaster scenes indeed helped them to keep calm in the real disaster."No" accounted for 3.41%, indicating that only a few people hold a negative attitude. Meanwhile, 24 people said "uncertain", accounting for 8.19%, answers from 37.2% were unclear, the highest percentage, which may reflect that some participants have doubts or have not thought deeply about the effectiveness of virtual reality in real disaster response. In the control group shown in Figure 35, the situation varied. The number of people who chose "yes" increased significantly to 129, accounting for 72.47%, far exceeding 51.19% of the experimental group, indicating that more people in the control group believed that the adaptation of virtual reality disaster scenarios had a positive role on calm response in real disaster events. The number of "no" is still small, at 7 people, accounting for 3.93%, slightly lower than the 3.41% in the experimental group. Although the number of people who chose "uncertain" is still 42, the proportion has decreased to 23.6%, lower than the 8.19% in the experimental group and the proportion of no answer. When assessing the help of VR disaster scenarios for calm response in real disasters, 72.47% of the control group with a positive attitude was significantly higher than 51.19% in the experimental group, indicating that the control group is more inclined to believe that virtual reality technology can improve their ability to respond to real disasters. In contrast, the proportion of "uncertain" of 8.19% was much higher than 23.6% in the control group, reflecting that more members of the experimental group had doubts or had no clear views about the utility of virtual reality technology. Meanwhile, although the proportion choosing "no" was lower in both groups, the control group was slightly higher than the experimental group, although this difference was not significant. Overall, the control group was more positive and positive about the effectiveness of the emergency training, while the experimental group showed more uncertainty and doubts.

Table 13 How do you consider the future development of VR in the field of emergency training (experimental group)

Multiple topic topics	N (count)	Response ratio (%)	Popularity rate (%)	X²	p-value
Good	188	56.627%	64.164%		
Very good	84	25.301%	28.669%		
Excellent	47	14.157%	16.041%		
Not necessarily	9	2.711%	3.072%	341.283	0.000***
Not good	4	1.205%	1.365%		
Amount to	332	100%	113.311%		

Note: ***, ** and * represent the significance levels of 1%, 5% and 10%, respectively

Table 14 How do you consider the future development of VR in the emergency training field (control group)

Multiple topic topics	N (count)	Response ratio (%)	Popularity rate (%)	X²	p-value
Good	15	57.692%	8.427%	28.615	0.000***

Multiple topic topics	N (count)	Response ratio (%)	Popularity rate (%)	X²	p-value
Very good	7	26.923%	3.933%		
Excellent	1	3.846%	0.562%		
Not necessarily	3	11.583%	1.685%		
Not good	0	0%	0%		
Amount to	26	100%	14.607%		

Note: ***, ** and * represent the significance levels of 1%, 5% and 10%, respectively

Table 13 shows the experimental group, in terms of response rate, "good" option achieved the highest response rate, reaching 56.627%, indicating that more than half of the respondents believed that VR has a good development prospect in the field of emergency training. This was followed by the "very good" and "very good" options, with response rates of 25.301% and 14.157%, respectively, indicating that a significant number of respondents supported the future development of VR in the field of emergency training with a very optimistic attitude. A total of 319 respondents chose "good", "good" very "and" very good " options, accounting for 96.085% of the total. This data clearly shows that more than 96% of the experimental group members have "good" cognition and evaluation of the application prospects of VR in the field of emergency training. Most of the experimental group members believe that VR technology has a good or very good development potential in the field of emergency training. This high proportion of optimism not only reflects the widespread recognition of VR technology in the field of emergency training but also provides a solid foundation for the further promotion and application of the technology in this field. In contrast, the "not necessarily" and "bad" options had lower response rates, at 2.711% and 1.205%, respectively, indicating that only a very few respondents were reserved or pessimistic about the future development of VR in the emergency training field. The significance level used in this study was 1% (***), the chi-square value was 341.283, and p-value=0.000 rejected the null hypothesis at the 1% significance level. In the control group Table 14, the respondent views were relatively concentrated. Similar to the experimental group, the "good" option also achieved the highest response rate of 57.692%, indicating that more than half of the respondents in the control group were optimistic about the future development of VR in the field of emergency training. However, unlike the experimental group, the response rate of the "very good" option ranked second, but only 26.923%, much lower than the 25.301% in the experimental group (although the comparison here is numerically close, the difference may be statistically significant considering the sample size and percentage significance).

A more striking difference is that the response rate for the "very good" option, only 3.846% in the control group, is much lower than the 14.157% in the experimental group.

Meanwhile, the response rate of the "not necessarily" option was relatively high in the control group, reaching 11.538%. It is noteworthy that no respondent chose the "bad" option in the control group."Good" had the highest share at 57.692%, followed by "Very good" at 26.923% and "very good" at 3.846%. In contrast, 11.538% chose "not necessarily", but not "bad" or "very bad" or "very bad""Options, or 0% of those with negative views on the future development of the sector. The chi-square value was 28.615, and p-value=0.000 rejected the null hypothesis at the 1% significance level. There are some similarities between the experimental and control groups regarding the future development prospects of VR emergency training, but there were also significant differences. The similarity is that more than half of respondents in both groups considered VR a good prospect in emergency training (the response rate for "good" options exceeded 50%). However, the percentage of respondents in the experimental group considered VR "good" and "very good" in emergency training was significantly higher than that in the control group, indicating that the experimental group was more optimistic about the future development of VR in emergency training. The relatively high proportion of respondents choosing "not necessarily" in the control group indicated that more respondents in the control group were wait-and-see or uncertain about the future development of VR in the field of emergency training. In conclusion, although the experimental and control groups had some agreement on the basic views of the future development prospects of VR emergency training, there were significant differences in optimism and uncertainty. These differences may stem from the absence of background, experience, or degree of knowledge of the VR technique in the two respondent groups.

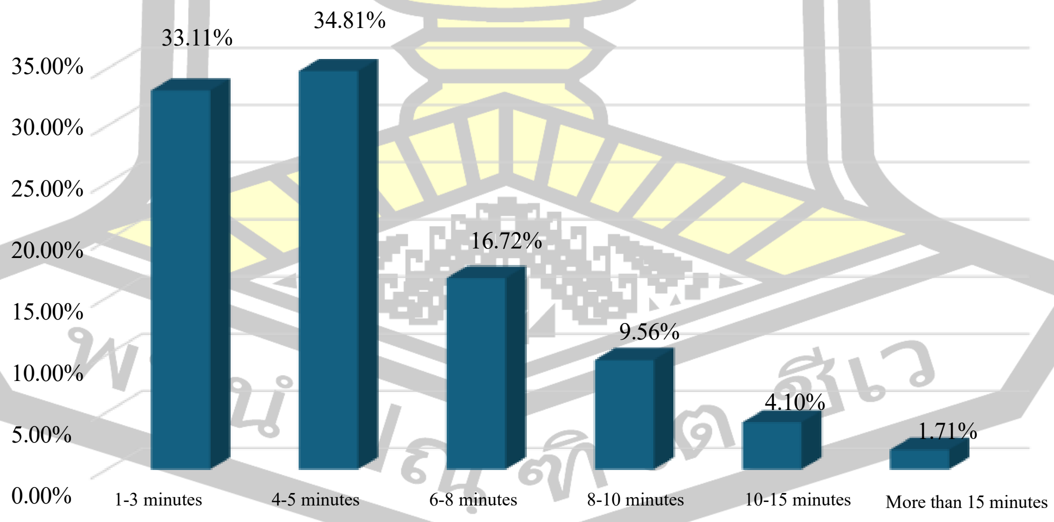

Figure 36 How long you took to escape your fire scene through your personal experience (experiment group)

According to Figure 36, 33.11% of respondents said they spent 1-3 minutes to escape from the fire, while 34.81% of respondents spent 4-5 minutes. These two combined time periods accounted for more than 67 percent, showing that the majority of respondents were able to respond quickly and successfully escape from the fire. Secondly, some respondents spent a relatively long time during the escape process. Among them, 16.72% of respondents said they spent 6-8 minutes, 9.56% spent 8-10 minutes, while 4.1% spent 10-15 minutes. Although these proportions are relatively low, they still deserve our attention, as prolonged escape times may increase the risk of injury or death. Only 1.71% of respondents said they spent more than 15 minutes to escape. Although this proportion is very small, it still reminds us that we should be calm and patient to find a safe escape path as quickly as possible. In conclusion, through this survey, we can find that most of the respondents can respond quickly and successfully escape from fire scenes, but some respondents spent a relatively long time. It is not clear whether the long time is because of the lack of fire knowledge or the unfamiliarity with the use of VR equipment. However, in any case, we need to further strengthen the popularization of fire prevention and escape knowledge and improve the public's awareness of fire safety and self-rescue ability in order to reduce the threat of fire to people's lives and property.

Table 15 for Chi-square analysis

Title	Name	For example, fire escape teaching, if it takes 45 minutes in the traditional classroom mode, you think it takes more for students to fully master it in VR mode long?					Amount to	Method of calibration	X^2	p-value
		Within 5 minutes	5-10 minutes	10-20 minutes	20-40 minutes	40 minutes or more				
How long you took to escape your fire scene through your personal experience?	1-3 minutes	36	29	15	10	7	97	pearson Chi-square test	61.646	0.000***
	4-5 minutes	20	49	21	9	3	102			
	6-8 minutes	3	20	17	8	1	49			
	8-10 minutes	1	5	11	10	1	28			
	10-15 minutes	1	5	5	1	0	12			
	More than 15 minutes	0	1	2	1	1	5			
	Amount to	61	109	71	39	13	293			

Note: ***, ** and * represent the significance levels of 1%, 5% and 10%, respectively

As seen from the data, most students have mastered the fire escape teaching in 5-10 minutes and 10-20 minutes, which together accounted for 61.4% of the total number of students. Fewer trainees required 40 minutes or more to master the teaching content, which may indicate that this group of trainees required more practice or coaching. Most users completed the VR fire escape scene within 1-5 minutes, indicating that VR technology can effectively improve learning efficiency while providing an immersive learning experience. Only a few users need more than 15 minutes to complete the scene, which may reflect their difficulties in operation or understanding. The significance level used in this study was 1% (***), with a chi-square value of 61.646 and a minimal p-value of 0.000 ***, indicating that the difference between the observed data and the expected distribution is significant. This may mean that the time required for students to master fire escape teaching in VR mode does not meet some expectations or assumptions, or that the percentage of students mastering teaching content varies significantly between different time periods. This significant difference may be influenced by many factors, such as learning ability, ease of VR technology, complexity of teaching content, etc. According to the survey results, most students master fire escape teaching in a relatively short time under the VR mode, which indicates that VR technology has great application potential in the field of education. For students who need a long time to master the teaching content, it is recommended to provide additional tutoring or practice opportunities to improve their learning efficiency. Considering the results of the Pearson chi-square test, it is recommended to further analyze the key factors affecting the mastery time and optimize the design of the teaching content and VR techniques to better meet the learning needs of the students.

In addition to questionnaire analysis, we also conducted interviews with all participants in the experimental and control groups, asking them about their understanding of VR defects and related suggestions in the form of Q&A, and performed word cloud analysis.

When we asked, "What do you think are the potential drawbacks of VR emergency teaching?" In the word cloud analysis of both the experimental and control groups, we found that most people did not mention specific VR devices or brands, filling in "none," while a few mentioned devices and brands such as "VR glasses." This shows the diversity of users in the use of VR devices.

When asked "What aspects do you hope to improve in VR emergency teaching?" in the word cloud analysis of the experimental group, we found that most people did not give specific feedback on certain issues, filling in "none." In the responses of a few people, keywords such as "comfort," "very good" (possibly referring to some kind of superiority in experience), "realistic," and "improve image quality" stood out, indicating users' high concern for the realism and image quality of VR experiences. In contrast, in the control group, although there were also some empty responses, the user feedback was more diverse. They raised needs in various aspects such as personal experience, accuracy, and scene richness, while words like "I don't know" and "no popularization" reflected users' limited knowledge and popularity of the product or service. In short, the experimental group focused more on the details of the experience, while the control group showed a wide range of expectations for the comprehensiveness and practicality of VR technology.

When asked " What expectations do you have for the application of VR technology in other fields?" in the word cloud of the experimental group, although most people chose not to fill in or left it blank, a few still put forward some key points. They valued the popularity, ease of use, and humanized design of the project, such as "wider application range," " more convenient to use," and specifically paid attention to "considering the specific use of myopic people." In addition, these users also expressed optimism about the social value and future prospects of the project and specifically proposed technical improvements, such as "hoping for sound synchronization and more modern technology." In contrast, the word cloud of the control group mainly reflected users' specific expectations in fields such as healthcare, education, and autonomous driving, as well as the needs for new technology investment and diversification of entertainment learning projects, although some ideas were expressed "not very clearly" due to their lack of professionalism or complexity. In short, the word cloud of the experimental group highlighted users' specific suggestions for project optimization and positive expectations.

When asked about the question "What do you want to improve in virtual reality emergency teaching?" In the word cloud map analysis of the experimental group, we found that most people did not give specific feedback on some questions and left them blank. With a small number of people, the keywords such as "comfort", "very good" (which may refer to some superiority in experience), "real" and "improving the picture quality" are more prominent, showing users high attention to the reality and picture quality of VR experience. In contrast, in the control group, although there are some vacancies, user feedback is more diversified. They put forward demands for personal experience, accuracy, scene richness, and other aspects. At the same time, words such as "not knowing" and "no popularity" reflect users' limited cognition and popularity of products or services. In short, the experimental group was more focused on the details of the experience, while the control group showed the users wide expectations for the comprehensiveness and practicality of VR technology.

Question "What do you expect about the application of VR technology in other fields?" In the word cloud map of the experimental group, although most people chose not to fill in or leave it blank, a few still raised some key points. They attached importance to the popularity, ease of use and humanized design of the project, such as "wider application range", "easier to use" and special attention to "consider the specific use of myopic people". In addition, these users are optimistic about the social value and future prospects of the project, and specifically make suggestions for technical improvements, such as "hope the sound will be synchronized and the technology will be more mature". In contrast, the comparison group mainly reflected users' specific expectations in medical, teaching, autonomous driving and other fields, as well as the need for new technology investment and diverse entertainment learning programs, although one of the ideas are "rather ambiguous" due to professionalism or complexity.

In short, the word cloud map of the experimental group highlights the users' specific suggestions and positive expectations for the project optimization.

4.4 The empirical from the results

4.4.1 Evaluation of the Practical Application of VR Technology

In the first instance, of the 293 participants in the experimental group surveyed, the gender distribution revealed that female participants accounted for a comparatively larger proportion of 73.04%, while male participants accounted for merely 26.96%. In the control group, where a survey was carried out on 178 participants, female participants accounted for 61.8%, while male participants accounted for 38.2%. This ratio reflected that in the field of emergency education, women play an indispensable role and have a higher acceptance and participation rate for VR technology. The education levels of members in both groups ranged from high school to doctoral degrees. It is evident that VR technology enjoys a wide application in emergency rescue skills training and is not restricted by educational levels.

Secondly, in terms of understanding virtual reality technology, 81.57% of respondents in the experimental group reported having some knowledge of the technology. Additionally, over 79% of respondents in the control group also indicated that they had some understanding of virtual reality. This demonstrates that virtual reality technology has gained a certain level of popularity among both groups.

In the study, 63.82% of respondents in the experimental group and 70.22% of those in the control group reported that they had not yet experienced virtual reality technology. Among those who had used it, the percentage of individuals who engaged with virtual reality on a "daily" or "weekly" basis was quite low, at just 1.69% and 1.12% respectively. This further highlights that the daily usage of virtual reality technology is not widespread.

Finally, by comparing the response rates of the experimental group and the control group for using virtual reality devices, we discovered that gaming and entertainment was the most common reason for using VR devices in both groups. Education and learning, virtual travel/fitness and sports, and vocational training also received responses in both groups, but the popularity rates were relatively low, indicating that the potential of VR applications in these fields has not been fully realized. Art creation and other purposes were engaged less frequently in both groups, but a certain market demand still exists. In summary, VR devices are most widely used in gaming and entertainment, but also show application potential in education, training, virtual travel/fitness and sports, etc. In the future, with continuous technological progress and cost reduction, VR is expected to be widely applied in more fields.

4.4.2 The Impact of Virtual Reality Training on Emergency Rescue Skills

Regarding the impact of VR on emergency rescue skills, the response rates of the experimental group and the control group to "virtual reality emergency teaching" were only 19.439% and 17.686% respectively, significantly lower than those of other teaching methods. It can also be seen that over 60% of the respondents indicated that their organizations had not yet used virtual reality technology for emergency training, and although a certain number of people had used it, it had yet to become mainstream. In both sample groups, the application of virtual reality technology in emergency training was similar and had yet to be widely adopted. This also reflects a certain degree of insufficient understanding or implementation obstacles regarding the value and potential of virtual reality technology in emergency training in both groups.

Illustrating a 30-minute offline fire safety course, we conducted a baseline survey on both groups who had yet to experience VR coaching. More than half of the participants in the experimental group were confident of mastering the content of fire escape teaching within 10 minutes in the VR mode, clearly demonstrating the potential of VR technology to improve learning efficiency. In the control group, a relatively higher proportion of participants believed it requires more than 20 minutes to master the content, indicating lower expectations from the control group in learning efficiency in VR teaching. Comparing the responses between the experimental and the control groups, it is generally believed that the former is able to master the content of fire escape teaching in a briefer period with the VR mode. This being the reason that the experimental group had experienced the effect of VR teaching firsthand and thus had a more intuitive understanding and confidence. More participants in the control group believed it would take 30 minutes or longer, which reflected their unfamiliarity or uncertainty with the VR teaching mode and their inertia towards the time required in traditional teaching methods. However, for the public, the number of participants willing to try the application of virtual reality technology in emergency rescue skills training was very high, with 87.37% in the experimental group and 70.79% in the control group. There were some variations in the questions asked to the experimental group compared to the control group. This was primarily because the experimental group's responses were informed by their experience with virtual reality (VR) equipment used for fire escape training. In contrast, the control group's answers were based solely on their own understanding and perceptions, as they had no experience with VR. The data collected from both groups was sufficient to indicate that there is a strong desire for virtual reality technology to be implemented in training for emergency rescue skills as soon as possible.

4.4.3 Public understanding and mastery of virtual reality technology

The comparative analysis revealed the response rates of the various indicators that show the significant differences in the aspects of virtual technology that required improvement or enhancement. The response rate related to "image quality and clarity" was the highest among participants, indicating that this issue is a primary concern for members of the experimental group. This was followed by "device comfort" and "mobility and operability." In contrast, topics such as "price and cost," "photo lag," "dizziness," and "user interface and interactive experience" received relatively low response rates, though they still garnered some attention. These results suggest that users have higher expectations and requirements concerning the overall performance and experience of virtual reality technology.

When asked about their satisfaction with virtual reality technology, most members of the experimental group rated their experience as "satisfied." In comparison, 88.76% of students in the control group did not provide a clear answer. This may indicate a lack of understanding of virtual reality technology, which hampers their ability to give an accurate satisfaction evaluation. The significant number of participants in the control group who could not provide a definitive response may also reflect insufficient experience or familiarity with virtual reality.

Regarding the future of virtual reality technology, most participants expressed a "very optimistic" outlook. It is noteworthy that 88.76% of the control group members selected the "(empty)" option when asked about VR discomfort, implying that they had not engaged with the technology and therefore could not assess its comfort. Conversely, the proportion of the experimental group selecting the "(empty)" option was much lower—49.85 percentage points less—indicating that the experimental group members experienced more significant discomfort during their training with virtual reality. These differences suggest that training with virtual reality may present more challenges and discomfort, highlighting the need for further attention and improvements.

4.4.4 Comparison between training based on virtual reality technology and traditional teaching methods

Of the advantages in VR teaching, respondents regarded "authenticity and immersive experience" as most crucial, Responses were received regarding "repeatable teaching," "personalized learning," "strengthening team cooperation," and "reducing training costs". There were notable differences between the experimental group and the control group regarding the most suitable settings for VR emergency teaching. However, "enterprise security training" was recognized as the most prominent setting by both groups. This was followed by "school emergency drills," "family emergency education," and "public place safety education".

Looking to the future of VR in emergency training, an impressive 96.085% of respondents expressed optimism about its development, choosing options like "good," "very good," and "excellent". When asked about the benefits of emergency and safety training, the most frequently selected advantages were "the portability and ease of use of the equipment," "interactive and operational experience," and "immersive, highly simulated, and diverse training scenarios".

In terms of the potential for virtual reality technology to replace traditional training methods, only 13.31% of the experimental group and 12.36% of the control group responded with "no." This suggests that a significant portion of respondents believes VR technology could replace traditional training methods either "in some cases" or "yes" in the future.

When asked utilizing VR technology to improve the coping ability and reaction speed in emergency training, participants in the experimental group and the control group selected "yes" 60.75% and 72.47% respectively, albeit with some being "uncertain". Only 3.41% and 2.81% decided on "no" respectively. It indicated the vast majority of members with a positive attitude towards the role of VR technology to improve the response speed and ability during emergency training. For the question on virtual reality disaster scenes being able to calm participants down in the event of real disasters, the percentages of the experimental group and the control group selecting "Yes" was 51.19% and 72.47% respectively, albeit with some "uncertain" choices. Only 3.41% and 3.93% chose "no". This gave an indication participants believed that adaptation to virtual reality disaster scenarios offer assistance to help them stay calm in real disasters and have a positive effect on the participants' coping with real disasters.

In our study, we organized a control group for a 45-minute fire escape class before implementing virtual reality (VR) training. Initially, most students in the experimental group believed they could master the fire escape training in just 5-10 minutes or 10-20 minutes, which accounted for 61.4% of the total participants. Only a small number of students thought it would take 40 minutes or more to learn the content.

After using the VR training, we found that 33.11% of the respondents were able to escape from the fire in just 1-3 minutes, while 34.81% took 4-5 minutes. Together, these two time periods represented more than 67% of the total responses. Although some individuals took more than 6 minutes, this may have been due to their unfamiliarity with the VR devices. Overall, the results indicate that VR training can significantly reduce the time required for fire escape instruction. Advantages of virtual reality (VR) technology in the field of emergency education

The VR teaching method is an innovative approach to emergency safety education that offers an immersive experience. It allows for personalized and repeatable instruction, providing significant advantages in areas such as "enterprise safety training," "school emergency drills," "family emergency education," and "public safety education."

This method enables students to quickly acquire essential disaster knowledge while also reducing the time spent on training. As a result, it enhances their ability to cope with emergencies and respond swiftly in crisis situations. Additionally, familiarizing individuals with disaster scenarios can help them remain calm during actual emergencies, positively impacting their reactions.

Furthermore, VR teaching can "enhance team collaboration" and "reduce training costs." The future of emergency training appears promising, as virtual reality technology is likely to replace traditional training methods in coming years.

4.5 Result Interpretation

After an in-depth analysis of the results, we found that the application of Virtual Reality (VR) technology to enhance emergency rescue skills has a significant effect.

The experimental group students, after receiving emergency rescue skill training using virtual reality technology, not only mastered more emergency knowledge and skills but also showed a significant improvement in response speed and ability when dealing with sudden incidents. This improvement is mainly due to the realism and immersive experience provided by virtual reality technology, which allows students to practice and simulate in a virtual environment repeatedly, thereby becoming more familiar with and mastering emergency rescue skills. The specific mechanism of action of virtual reality technology in enhancing emergency rescue capabilities is mainly reflected in the following aspects

Firstly, by providing a realistic and immersive experience, it enhances students' sense of immersion and participation. VR technology provides learners with a highly realistic simulated environment, allowing them to experience emergency scenarios in a virtual space, thereby enhancing their intuitive feelings and practical abilities for emergency rescue skills. This immersive way of experiencing, compared to traditional classroom teaching or graphic displays, can better stimulate learners' interest and enthusiasm for participation, thereby improving learning outcomes.

Secondly, by simulating real emergency scenarios, virtual reality (VR) enables students to practice in a controlled environment. In VR emergency training, learners can select appropriate content and difficulty levels based on their individual needs and progress, allowing for targeted skill development.

Thirdly, through a real-time feedback and assessment system, it corrects mistakes and improves levels. The VR system provides real-time feedback and assessment based on learners' performance, helping to identify errors and deficiencies in teaching in a timely manner. At the same time, it helps them correct mistakes in a timely manner and improve their skill levels.

Fourthly, VR technology has significantly shortened the training time, improving time efficiency.This shortening of time not only improves training efficiency but also provides learners with more practice opportunities and feedback time, which helps them form and consolidate emergency rescue skills quicker.

However, despite the tremendous potential and advantages of VR technology in emergency rescue skill training, we may still encounter some problems and challenges in practical applications. For example, high equipment costs may limit the popularization and application range of VR technology; some individuals may feel uncomfortable or face difficulty adapting to the use of virtual reality equipment; some individuals may encounter difficulties in understanding the plot or visual limitations when using VR equipment for training. On one hand, these problems affect their learning experience and outcomes, on the other hand, although VR technology has shortened the training time, how to ensure that learners fully understand and master emergency rescue skills within a limited time still needs further research and exploration. Therefore, in the future application process, it is necessary to continuously pay attention to and solve these problems and challenges to promote the widespread application and development of virtual reality technology in emergency rescue skill training.

CHAPTER V

CONCLUSION DISCUSSION AND RECOMMENDATION

Based on the research on the application of Virtual Reality (VR) technology in emergency rescue skill training, we have reached the following

5.1 Conclusions

Virtual reality (VR) technology is highly regarded in emergency rescue education. Experimental results demonstrate that VR offers significant advantages by providing authentic and immersive experiences. This has garnered widespread recognition from participants in both the experimental and control groups. In particular, during emergency scenarios like fire escape drills, VR technology can create highly realistic environments, effectively enhance the emergency response capabilities of participants.

The popularization and application of VR equipment are diverse, and the study found that VR equipment is most widely used in the fields of gaming entertainment and education. In the experimental group, the frequency of VR being used for emergency rescue skill training is higher than in the control group, indicating that VR technology has potential for development in the field of professional training.

There is a need for further optimization in technology and user experience. Respondents in the experimental group believe that VR technology can improve in areas such as image quality, equipment comfort, mobility, and operability. Notably, image quality, clarity, and equipment comfort are crucial factors in enhancing the effectiveness of VR technology for emergency rescue education.

The substitutive role of VR technology in emergency training, more than half of the respondents in the experimental group believe that VR technology has the potential to fully replace traditional training methods in emergency training. Although this view is not as widespread in the control group as in the experimental group, it also shows the application prospects of VR technology in the field of emergency training.

5.2 Discussions

This discusses the findings of the study on the application of Virtual Reality (VR) technology to enhance emergency rescue training at the Sichuan Disaster Prevention and Reduction Museum. The discussion integrates empirical data from the research with insights from relevant literature, addressing the effectiveness of VR, learner attitudes and behavioral responses, existing barriers, broader societal implications, and theoretical contributions.

Effectiveness of VR in Emergency Training

The results of this study clearly indicate that VR-based training significantly improves the efficiency and efficacy of emergency rescue skill acquisition. Participants in the experimental group demonstrated a faster and more accurate understanding of fire escape procedures, with over 60% mastering the content within 5–10 minutes, compared to the traditional classroom group, where comprehension took approximately 30 minutes. These findings are supported by Mao et al. (2021), who observed that immersive VR simulators enabled learners to complete surgical tasks more rapidly and accurately than those trained through conventional means. Similarly, Barteit et al. (2021) reported that VR-based tracheostomy training improved healthcare providers' knowledge retention, confidence, and technical performance. Jung and Younhyun (2022) further emphasized the advantages of VR in hospital-based disaster drills, particularly its ability to deliver reproducible, cost-effective training with measurable learning gains. The present study extends these conclusions by demonstrating that VR can provide similar benefits in a public education context, supporting its broader applicability beyond clinical or professional environments.

Learner Attitudes and Behavioral Changes

In addition to measurable learning outcomes, the study highlighted significant shifts in learners' attitudes toward emergency preparedness. An overwhelming 87% of participants in the VR group expressed a strong willingness to continue using VR technology for emergency training. Many also reported feeling more calm, confident, and prepared for real-world emergencies after undergoing the immersive training experience. These findings resonate with those of Saab et al. (2022), who found that nursing students trained using VR expressed positive emotions, deeper engagement, and stronger recall of content. Halbig et al. (2022) similarly concluded that end-user perception of utility and ease-of-use are vital for fostering positive attitudes and adoption. Moreover, Abbas, Chu, et al. (2023) highlighted that VR training can reduce anxiety and improve empathy in healthcare contexts. This study reinforces the notion that immersive training environments not only improve technical understanding but also instill a sense of personal responsibility and behavioral readiness in diverse user groups.

Barriers and Limitations of VR Training

Despite the positive outcomes, several barriers to effective VR implementation were identified. Participants reported discomfort related to headset ergonomics, dizziness, and difficulty navigating unclear scenario prompts. Approximately 31% of experimental participants suggested improvements in image quality and equipment comfort. These concerns are consistent with findings from Kouijzer et al. (2023), who highlighted the fragmented and often unstructured nature of VR implementation across healthcare systems. Mäkinen et al. (2022) noted similar issues with hardware usability and user interface design in educational simulations. Furthermore, Khanal et al. (2022) underscored the lack of standardization and insufficient user onboarding as persistent challenges to XR adoption. The control group's limited exposure to VR further revealed a gap in public accessibility and familiarity, suggesting that future implementation strategies must address technical onboarding and inclusive design principles to ensure broader societal adoption.

Broader Application and Social Impact

This study offers significant contributions to the discourse on disaster education by demonstrating the viability of VR training in a large-scale, non-clinical setting. The Sichuan Disaster Prevention and Reduction Museum served as an ideal platform for public engagement, offering immersive simulations to diverse demographic groups. The participants' support for implementing VR in enterprise safety, school emergency drills, and community education aligns with broader global trends. Abdelmaged Mohamed and Adel Mahmoud (2021) emphasized the potential of VR across multiple sectors, including tourism, education, and retail. Bhugaonkar et al. (2022) similarly advocated for the Metaverse as a comprehensive, immersive extension of digital training environments. Loke et al. (2021) identified VR as a critical tool in the evolution of global disaster nursing curricula. This study advances those discussions by offering empirical evidence from a real-world public safety context, thereby supporting China's national goals under the Sendai Framework and the Red Cross objective to certify 28 million first responders by 2030.

Theoretical and Practical Implications

The findings of this study are grounded in, and contribute to, established theoretical models. Kolb's Experiential Learning Theory is exemplified through the immersive, hands-on learning afforded by VR, which engages learners in a continuous cycle of experience, reflection, and application. Participants developed a deeper, more intuitive understanding of emergency scenarios by interacting directly with virtual environments. Additionally, the results support the Technology Acceptance Model (TAM) proposed by Davis (1989), where perceived usefulness and ease of use significantly influenced participants' positive evaluations of the training system. Kouijzer et al. (2023) emphasized the need for structured, theory-informed implementation processes to ensure successful technology integration. This study adds that such integration must also consider behavioral factors, stakeholder attitudes, and infrastructure readiness. Practically, the research suggests that future programs should incorporate tailored content design, technical training for facilitators, and mechanisms for real-time feedback. These steps will be essential for integrating VR into national-level disaster education strategies.

5.3 Recommendations

1) Optimize training content design. Based on the actual needs of emergency rescue, design more targeted and practical VR training content. Introduce more diversified emergency scenarios, such as production safety, school safety education, and family safety education, as well as earthquakes, floods, and other natural disasters, to enhance the comprehensiveness of training.

2) Update technology and equipment. Improve the image quality and clarity of VR equipment to enhance the visual effects of training. Improve equipment comfort, such as optimizing the weight and wearing method of head-mounted displays, to reduce user fatigue. Enhance the mobility and operability of equipment to meet the training needs of different emergency scenarios.

3) Promote the widespread application of VR technology in the field of emergency rescue. Encourage relevant decision-makers and practitioners to pay attention to the development of VR technology and promote its widespread application in the field of emergency rescue.

4) Support the implementation of VR technology in corporate safety training, school emergency drills, and other scenarios to enhance the public's emergency rescue capabilities.

5.4 Research Limitations and Outlook

Analyze the limitations of the research and propose directions and suggestions for future research.

Limitations:

1) Although this study has achieved certain results, the sample size is limited and mainly concentrated in the Sichuan region, which may affect the universality of the research results.

2) Currently, VR technology is still in a rapid development stage, and the performance of some technologies and equipment has not yet fully matured, which may have a certain impact on the research results.

3) This study mainly evaluates the effectiveness of VR technology in emergency rescue skill training through questionnaires and interviews, which may have some subjectivity and bias.

Outlook:

1) Expand the scope and sample size of the study, future research should expand the sample size and geographical scope to improve the universality and accuracy of the research results.

2) Focus on technology development trends, with the continuous advancement and cost reduction of VR technology, future research should focus on the application effects of new technologies and new equipment in emergency rescue skill training.

3) Improve the training effectiveness evaluation system, establish a more scientific and objective evaluation system to comprehensively and accurately evaluate the effectiveness of VR technology in emergency rescue skill training, and provide more reliable scientific basis and practical guidance for relevant decision-makers and practitioners.

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REFERENCES

Abbas, J. R., Chu, M. M., Jeyarajah, C., Isba, R., Payton, A., McGrath, B., Tolley, N., & Bruce, I. (2023). Virtual reality in simulation-based emergency skills training: A systematic review with a narrative synthesis. *Resuscitation Plus*, *16*, 100484.

Abbas, J. R., O'Connor, A., Ganapathy, E., Isba, R., Payton, A., McGrath, B., Tolley, N., & Bruce, I. A. (2023). What is virtual reality? A healthcare-focused systematic review of definitions. *Health Policy and Technology*, *12*(2), 100741.

Abdelmaged Mohamed, & Adel Mahmoud. (2021). Implementation of virtual reality in healthcare, entertainment, tourism, education, and retail sectors.

Almukhlifi, Y., Crowfoot, G., Wilson, A., & Hutton, A. (2021). Emergency healthcare workers' preparedness for disaster management: an integrative review. *Journal of clinical nursing*.

Amico, A., Bernardini, G., Lovreglio, R., & Quagliarini, E. (2023). A non-immersive virtual reality serious game application for flood safety training. *International journal of disaster risk reduction*, *96*, 103940.

Aoki, H., Oman, C. M., Buckland, D. A., & Natapoff, A. (2008). Desktop-VR system for preflight 3D navigation training. *Acta astronautica*, *63*(7-10), 841-847.

Ardiny, H., & Khanmirza, E. (2018). The role of AR and VR technologies in education developments: opportunities and challenges. 2018 6th rsi international conference on robotics and mechatronics (icrom),

Assembly, U. N. G. (2005). *Hyogo Declaration* https://www.un.org/zh/node/181911

Barteit, S., Lanfermann, L., Bärnighausen, T., Neuhann, F., & Beiersmann, C. (2021). Augmented, mixed, and virtual reality-based head-mounted devices for medical education: systematic review. *JMIR serious games*, *9*(3), e29080.

Bernardes, S. M. F., Rebelo, F., Vilar, E., Noriega, P., & Borges, T. (2015). Methodological approaches for use virtual reality to develop emergency evacuation simulations for training, in emergency situations. *Procedia Manufacturing*, *3*, 6313-6320.

Bhugaonkar, K., Bhugaonkar, R., & Masne, N. (2022). The trend of metaverse and augmented & virtual reality extending to the healthcare system. *Cureus*, *14*(9).

Chana, M. o. E. M. o. t. P. i. R. o. (2022). *14th Five-Year Plan National Comprehensive Disaster Prevention and Reduction Plan I* https://www.mem.gov.cn/gk/zfxxgkpt/fdzdgknr/202207/t20220721_418698.shtml

Chang, C.-W., Lin, C.-W., Huang, C.-Y., Hsu, C.-W., Sung, H.-Y., & Cheng, S.-F. (2022). Effectiveness of the virtual reality chemical disaster training program in emergency nurses: a quasi experimental study. *Nurse education today*, *119*, 105613.

Chen, H., Hou, L., Zhang, G. K., & Moon, S. (2021). Development of BIM, IoT and AR/VR technologies for fire safety and upskilling. *Automation in Construction*, *125*, 103631.

Chen, S.-Y., Lai, Y.-H., & Lin, Y.-S. (2020). Research on head-mounted virtual reality and computational thinking experiments to improve the learning effect of AIoT maker course: case of earthquake relief scenes. *Frontiers in psychology*, *11*, 1164.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, 319-340.

Duan, Y.-y., Zhang, J.-y., Xie, M., Feng, X.-b., Xu, S., & Ye, Z.-w. (2019). Application of virtual reality technology in disaster medicine. *Current medical science*, *39*, 690-694.

Feng, Z., González, V. A., Mutch, C., Amor, R., Rahouti, A., Baghouz, A., Li, N., & Cabrera-Guerrero, G. (2020). Towards a customizable immersive virtual reality serious game for earthquake emergency training. *Advanced Engineering Informatics*, *46*, 101134.

Halbig, A., Babu, S. K., Gatter, S., Latoschik, M. E., Brukamp, K., & Von Mammen, S. (2022). Opportunities and challenges of virtual reality in healthcare–a domain experts inquiry. *Frontiers in Virtual Reality*, *3*, 837616.

Handy, M., & Brun, J.-P. (2004). Seismicity, structure and strength of the continental lithosphere. *Earth and Planetary Science Letters*, *223*(3-4), 427-441.

Holtslag, A., Svensson, G., Baas, P., Basu, S., Beare, B., Beljaars, A., Bosveld, F., Cuxart, J., Lindvall, J., & Steeneveld, G. (2013). Stable atmospheric boundary layers and diurnal cycles: challenges for weather and climate models. *Bulletin of the American Meteorological Society*, *94*(11), 1691-1706.

Hong, J.-C., Chan, H.-Y., Teng, Y.-H., Tai, K.-H., & Lin, C.-Z. (2023). Vr training program for fire escape: Learning progress predicted by the perception of fire presence, vr operational frustration, and gameplay self-efficacy. *Computers & Education: X Reality*, *3*, 100029.

Hubail, D., Mondal, A., Al Jabir, A., & Patel, B. (2022). Comparison of a virtual reality compression-only Cardiopulmonary Resuscitation (CPR) course to the traditional course with content validation of the VR course–A randomized control pilot study. *Annals of Medicine and Surgery*, *73*, 103241.

Jung, & Younhyun. (2022). Virtual reality simulation for disaster preparedness training in hospitals: integrated review. *Journal of Medical Internet Research*, *24*(1), e30600.

Khanal, S., Medasetti, U. S., Mashal, M., Savage, B., & Khadka, R. (2022). Virtual and augmented reality in the disaster management technology: a literature review of the past 11 years. *Frontiers in Virtual Reality*, *3*, 843195.

Kočkár, S., Hollá, K., Ďaďová, A., & Gaňa, J. (2023). The use of mixed reality scenarios for training crisis managers and emergency responders in an ADR tanker accident. *Transportation Research Procedia*, *74*, 1452-1457.

Kolb, D. A. (2014). *Experiential learning: Experience as the source of learning and development*. FT press.

Kouijzer, M. M., Kip, H., Bouman, Y. H., & Kelders, S. M. (2023). Implementation of virtual reality in healthcare: a scoping review on the implementation process of virtual reality in various healthcare settings. *Implementation science communications*, *4*(1), 67.

Loke, Yuen, A., Guo, Chunlan, Molassiotis, & Alex. (2021). Development of disaster nursing education and training programs in the past 20 years (2000–2019): A systematic review. *Nurse education today*, *99*, 104809.

Lønne, T. F., Karlsen, H. R., Langvik, E., & Saksvik-Lehouillier, I. (2023). The effect of immersion on sense of presence and affect when experiencing an educational scenario in virtual reality: A randomized controlled study. *Heliyon*, *9*(6).

Lorini, V., Rando, J., Saez-Trumper, D., & Castillo, C. (2020). Uneven coverage of natural disasters in Wikipedia: The case of flood. *arXiv preprint arXiv:2001.08810*.

Ma Ying, Z. Y., Li Jialin and Xie Yushi. (2020). Application of Vr technology in Disaster education. *Satellite Television and Broadband Multimedia*, *1*, 39-40.

Mäkinen, H., Haavisto, E., Havola, S., & Koivisto, J.-M. (2022). User experiences of virtual reality technologies for healthcare in learning: an integrative review. *Behaviour & Information Technology*, *41*(1), 1-17.

Mao, R. Q., Lan, L., Kay, J., Lohre, R., Ayeni, O. R., & Goel, D. P. (2021). Immersive virtual reality for surgical training: a systematic review. *Journal of Surgical Research*, *268*, 40-58.

Oki, T., Entekhabi, D., & Harrold, T. I. (1999). The global water cycle. *Global energy and water cycles*, *10*, 27.

Rispoli, G. (2023). Planetary environing: The biosphere and the Earth system. In *Environing Media*. Taylor & Francis.

Saab, M. M., Landers, M., Murphy, D., O’Mahony, B., Cooke, E., O’Driscoll, M., & Hegarty, J. (2022). Nursing students’ views of using virtual reality in healthcare: A qualitative study. *Journal of clinical nursing*, *31*(9-10), 1228-1242.

Samadbeik, M., Yaaghobi, D., Bastani, P., Abhari, S., Rezaee, R., & Garavand, A. (2018). The applications of virtual reality technology in medical groups teaching. *Journal of advances in medical education & professionalism*, *6*(3), 123.

Shujuan, L., Mawpin, T., Meichan, C., Weijun, X., Jing, W., & Biru, L. (2022). The use of virtual reality to improve disaster preparedness among nursing students: a randomized study. *Journal of nursing education*, *61*(2), 93-96.

T., Z. X. (2020). Research on the strategy of emergency rescue knowledge popularization and the construction of training system. *Modern Education Forum*, *3*(7), 88-90.

van der Kruk, S. R., Zielinski, R., MacDougall, H., Hughes-Barton, D., & Gunn, K. M. (2022). Virtual reality as a patient education tool in healthcare: A scoping review. *Patient Education and Counseling*, *105*(7), 1928-1942.

Webster, N. (1988). *Webster's ninth new collegiate dictionary*. Merriam-Webster.

Xu, J., Tang, Z., Yuan, X., Nie, Y., Ma, Z., Wei, X., & Zhang, J. (2018). A VR-based the emergency rescue training system of railway accident. *Entertainment Computing*, *27*, 23-31.

Xue, S., Hu, L., Yongliang, T., Guanghui, W., & Yuan, G. (2020). Team effectiveness evaluation and virtual reality scenario mapping model for helicopter emergency rescue. *Chinese Journal of Aeronautics*, *33*(12), 3306-3317.

You, S. H., Jang, S. H., Kim, Y. H., Kwon, Y. H., Barrow, I., & Hallett, M. (2005). Cortical reorganization induced by virtual reality therapy in a child with hemiparetic cerebral palsy. *Developmental Medicine & Child Neurology*, *47*(9), 628-635.

Yu, S. (2022). Application of VR Intelligent Technology in Fire Evacuation Simulation of Urban Rail Transit Station. *Procedia Computer Science*, *208*, 223-230. https://doi.org/https://doi.org/10.1016/j.procs.2022.10.033

Zhu, Y., & Li, N. (2021). Virtual and augmented reality technologies for emergency management in the built environments: A state-of-the-art review. *Journal of safety science and resilience*, *2*(1), 1-10.

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