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INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)
(Int Peer Reviewed Journal)
Vol. 05, Issue 04, April 2025, pp : 297-307

e-ISSN : 2583-1062
Impact Factor : 7.001

FLAME GUARD VR

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DOI: https://www.doi.org/10.58257/IJPREMS39615

ABSTRACT

Numerous educational institutions currently lack structured training and practical exercises related to evacuation protocols for fire emergencies. This deficiency in hands-on training, coupled with insufficient awareness among both students and educators regarding appropriate responses to fire threats, has resulted in considerable risks, leading to avoidable injuries and, in some instances, fatalities. To tackle this challenge, the present study proposes the creation of a Virtual Reality (VR) game prototype specifically aimed at simulating fire evacuation scenarios within a school environment. The primary objective of this VR game is to actively involve students in mastering essential fire safety procedures, allowing them to experience emergency situations within a controlled virtual setting where they can practice and internalize vital protocols.Through engagement with the VR game, students will learn how to respond effectively during a fire, including the necessary steps for safe evacuation, maintaining order, and assisting others. The game's interactive features and realistic simulations motivate users to explore escape routes, identify safe exits, and appreciate the significance of remaining calm and adhering to instructions. These experiences are crucial for cultivating a foundational "safety culture" within the school, promoting awareness, preparedness, and responsibility among students.

1. INTRODUCTION

Flame Guard VR is an advanced virtual reality training application designed using Roblox software to provide users with a comprehensive fire safety training experience. Traditional fire safety training methods, such as lectures and video demonstrations, often lack practical engagement, and hands-on training can be costly and hazardous to organize. Flame Guard VR addresses these limitations by offering an interactive and immersive virtual environment where users can safely practice crucial fire safety techniques, including the PASS method (Pull, Aim, Squeeze, Sweep), which is widely recognized in firefighting practices.

Using Roblox's robust capabilities for VR development, Flame Guard VR provides high-quality, realistic graphics and intuitive interactions, making the training experience engaging and memorable. Users navigate a lifelike environment where they can learn to assess fire hazards, use fire extinguishers effectively, and make quick, informed decisions in emergency scenarios. This practical approach helps reinforce theoretical knowledge through realistic practice, increasing retention and confidence in handling fire-related emergencies.

Flame Guard VR is designed for diverse applications, including workplaces, educational institutions, and safety organizations. Employees, students, and safety personnel can all benefit from the immersive training it provides, allowing them to become familiar with fire safety practices in a controlled, risk-free setting. This application offers two main training modes: an interactive VR mode, where users can practice directly within the virtual environment, and a video training option, which allows users without VR equipment to benefit from visual demonstrations and safety tips. Overall, Flame Guard VR provides a practical, accessible, and cost-effective solution to fire safety training, preparing users for real-world emergencies in a way that is both engaging and efficient. By combining immersive technology with essential safety knowledge, Flame Guard VR aims to improve preparedness and response to fire incidents across various industries and communities.

2. LITERATURE SURVEY

In the paper [1] Virtual Reality (VR) is transforming fire safety training by tackling the high expenses, logistical obstacles, and low engagement that come with conventional approaches. "Fire Guard VR," a virtual reality fire extinguisher training app created using Roblox Studio, enables users to practice using fire extinguishers in lifelike, immersive environments. This virtual setup offers a secure, controlled atmosphere where users can tackle various fire scenarios, boosting their confidence and comprehension without the dangers associated with real-life drills. In a usability study involving 57 participants, 79% reported increased confidence in managing fire emergencies after engaging with Fire Guard VR, and an impressive 96.5% preferred this method over traditional training techniques. By minimizing costs, offering scalability, and enhancing knowledge retention, Fire Guard VR demonstrates the significant potential of

VR to enhance the effectiveness and accessibility of fire safety training across corporate, residential, and other fields. In the paper [2] Fire safety training has historically relied on face-to-face drills and theoretical education. Nevertheless, recent advancements in Building Information Modeling (BIM), the Internet of Things (IoT), and immersive technologies such as Augmented Reality (AR) and Virtual Reality (VR) have revolutionized this area. BIM facilitates the comprehensive mapping and evaluation of building layouts, leading to enhanced fire prevention and safety management. IoT aids by providing real-time monitoring and data transmission, delivering crucial alerts and information during emergencies. AR and VR have opened up innovative training methods, offering lifelike fire simulation scenarios where individuals can safely practice emergency responses. Studies indicate that VR and AR training improve information retention and user participation, enabling practical experience without the dangers associated with real fire drills. Together, these technologies offer a safer, more accessible, and efficient way to train for fire safety and enhance personnel skills. In the paper [3] Fire safety and evacuation training are essential elements of ensuring school safety; however, conventional fire drills and theoretical instruction often fall short in terms of practical involvement, particularly in Brazil, where the fire safety culture is still developing. The research conducted by Rodrigues de Carvalho et al. explores the application of Serious Games (SG) for fire evacuation training in educational institutions, emphasizing the advantages of interactive methods to enhance student comprehension and retention of safety procedures. Serious Games used in fire safety education create immersive and realistic experiences, enabling users to refine their emergency responses without facing actual dangers. Previous studies have shown that digital games are potent learning instruments, promoting knowledge retention, engagement, and improved safety actions, especially in preparing for emergencies. Investigations into augmented reality (AR) and virtual reality (VR) games for disaster management, such as the Tactical Language and Culture Training System and Zero Focus, highlight the success of immersive learning in fostering a safety culture. This body of literature emphasizes the promise of digital simulations in cultivating a proactive attitude towards safety, affirming the value of integrating game-based training into school safety protocols. In the paper [4] the drawbacks of conventional fire safety training techniques, such as lectures and evacuation exercises, often result in less engaging and contextually relevant learning experiences. While traditional approaches can be effective in certain areas, they may not provide the realism and feedback mechanisms necessary for enhancing knowledge retention and self-confidence among participants. Extended reality (XR) technologies, such as augmented reality (AR) and virtual reality (VR), present potential benefits for improving training effectiveness. Although VR has been widely studied in various contexts, it requires a completely virtual environment, which can lead to problems like motion sickness and fails to ground trainees in the real-world settings they would encounter during an actual emergency.In contrast, AR merges virtual components with real-world environments, thereby enhancing the realism and contextual relevance of training. Research has indicated that AR can increase user engagement and intrinsic motivation, making it a useful resource for fire safety education. Previous studies have utilized AR in safety-related domains, frequently demonstrating its advantages for knowledge gain, motivation, and performance on tasks. Specifically, AR's ability to superimpose emergency instructions onto real-world visuals enhances faster and more intuitive decision-making during fire evacuations. In the paper [5] Research increasingly highlights the importance of combining Building Information Modelling (BIM) and Augmented Reality (AR) to improve fire evacuation effectiveness in dynamic settings such as construction sites. Conventional 2D evacuation diagrams can hinder user comprehension, particularly in complex or high-risk buildings. BIM facilitates accurate, up-to-date mapping and visualizations, providing adaptable 3D layouts that respond to the current conditions of the building, while AR overlays crucial information onto the physical environment, including directional arrows, exit routes, and real-time hazard notifications, thereby enhancing situational awareness. The study by Kanangkaew et al. focuses on a marker-based method where physical markers within a building connect users to virtual guidance, enhancing navigation through auditory and visual signals. The findings indicated that this approach resulted in more accurate navigation and quicker evacuation paths compared to traditional laser-based systems, highlighting the benefits of integrating BIM and AR for effective emergency preparedness. In the paper [6] the journal examines the evolution and design patterns of immersive head-mounted display virtual reality (HMD-VR) health games that aim to improve therapeutic engagement. By analysing literature published from 2015 onward, the study identifies 29 HMD-VR health games that concentrate on domains such as physical exercise, motor rehabilitation, and pain alleviation. The results indicate that the majority of games utilize obstacle challenges and reward mechanisms, while narrative-driven approaches are less common. The authors highlight the importance of user-centred design and a systematic focus on game design elements, suggesting future enhancements in participatory design to boost user engagement and therapeutic effectiveness. In the paper [7] This paper review assesses the use of immersive virtual reality (IVR) as a supplementary therapy for managing acute pain in clinical settings. Through a rapid evidence assessment (REA) of 17 studies involving 337 patients, the review finds that IVR can offer immediate pain reduction and some functional benefits without significant adverse effects. Although effective for short-term pain relief, evidence

for long-term benefits remains limited. The review recommends further research to establish IVR's efficacy across broader pain types and explore its potential as a cost-effective, non-pharmacological pain management tool. In the paper [8] The MDA framework (Mechanics, Dynamics, Aesthetics) presents a systematic approach to game design, integrating development, research, and critique. Created for the Game Developers Conference, MDA clarifies game design by categorizing games into mechanics (rules and data), dynamics (player interactions during the game), and aesthetics (emotional reactions). This framework aids in the iterative refinement of games, ensuring that design choices align with user experience objectives. MDA offers a common terminology for discussing and analysing games, improving understanding among designers, researchers, and academics, and promoting the development of games that appeal to a variety of player preferences and experiences. In the paper [9] the journal article examines the application of virtual reality (VR) as a complementary, nonpharmacological approach to pain management for adolescent burn patients during wound care procedures. Two case studies demonstrated a notable decrease in pain when VR was implemented in conjunction with standard opioid medications, in contrast to the use of regular video games. The immersive qualities of VR shifted the patients' attention, leading to a reduction in pain perception, anxiety, and distress. The results indicate that VR could serve as an effective distraction method for alleviating acute pain in clinical environments. Further investigation could look into the long-term effectiveness and broader applications of VR across various patient groups. In the paper [10] This paper performs a SWOT analysis of the use of virtual reality (VR) in rehabilitation and therapeutic settings, focusing on its strengths, weaknesses, opportunities, and threats. The strengths of VR include its ability to provide realistic and controlled simulations that support both physical and cognitive recovery. The weaknesses consist of high expenses, technical difficulties such as a restricted field of view, and intricate user interfaces. There are opportunities stemming from advancements in VR technology, both in hardware and software, as well as an increasing interest from the public and healthcare professionals. The threats encompass financial obstacles, limited acceptance within clinical settings, and worries regarding VR's influence on conventional therapy practices.

3. HARDWARE & SOFTWARE REQUIRED

3.1 Oculus Quest Hardware

The Oculus Quest, developed by Oculus VR, a division of Meta Platforms, is a line of all-in-one virtual reality (VR) headsets that provide an immersive VR experience without the need for external sensors or a connected PC. Equipped with six degrees of freedom (6DoF) tracking and built-in cameras, the Quest headsets track the user's head and hand movements accurately in 3D space. This feature enables users to move naturally within the virtual environment, offering a high level of immersion. The Oculus Touch controllers are designed to closely mimic hand movements, providing intuitive interactions in VR. Users can reach, grab, and manipulate objects within the virtual space, making the experience more realistic and engaging. With the Quest series, Oculus combines high-resolution displays, spatial audio, and powerful processors to deliver high-quality graphics and sound. The standalone nature of the Quest headsets makes them accessible to a wide range of users, as they do not require additional hardware or cables. Additionally, The Quest supports a vast library of games, training applications, and social VR experiences, accessible through the Oculus Store.

3.2 Roblox studio

Roblox Studio is a robust game development platform that allows users to create, design, and program their own interactive experiences on the Roblox platform. By utilizing the Lua programming language, developers can personalize game mechanics, construct engaging worlds, and improve gameplay. The platform features an extensive collection of assets, templates, and plugins, making it user-friendly for both novices and seasoned developers. Roblox is not merely a gaming platform; it promotes creativity, education, and social interaction. With millions of active users, it provides developers with avenues to display their creations, collaborate with others, and generate income through in-game transactions. Additionally, it acts as an educational resource, imparting knowledge in coding and game design. As an expanding metaverse, Roblox is instrumental in influencing the future of online gaming and interactive digital experiences

4. METHODOLOGY

4.1. Game Plan and Environment Design

The first step in the suggested approach is creating a thorough game strategy and environment design that describes user interactions, training scenarios, and fire safety goals. Critical duties including detecting fire threats, choosing the appropriate kind of extinguisher, and adhering to fire safety procedures are identified during this phase.

To give users practical experience reacting to fire accidents, the virtual environment is made to mimic actual emergency scenarios.

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4.2. VR Model Creation

The creation of the VR model begins with gathering essential building information, including room layouts, exit paths, and fire extinguisher placements. This meticulous process ensures that the virtual environment closely mirrors real-world settings, enhancing the realism and effectiveness of fire safety training. In addition to structural accuracy, the model incorporates interactive elements such as fire extinguishers, water hose. Each of these components is carefully designed and scripted to behave realistically, allowing users to engage in hands-on learning. For example, fire extinguishers operate based on their real-world mechanics, requiring proper handling techniques. By integrating these detailed elements, the VR training environment provides an immersive, engaging, and educational experience, helping users develop crucial fire safety skills in a controlled and realistic setting.

4.3. Scripting and Game Control

The system leverages Lua scripting in Roblox Studio to control the behaviour of players and models within the game. Player scripting handles user actions, including movement, interactions with fire extinguishers, and decision-making during emergency scenarios. Model scripting governs the behaviour of objects, ensuring that fire spreads realistically and that extinguishers respond correctly to user actions. The scripts are integrated to play and run the game, delivering a smooth and interactive experience.

4.4. Training Options

Users can choose between two training modes based on their access to VR equipment:

VR Training: Provides an immersive, hands-on learning experience where users practice fire safety protocols in a virtual environment. This mode simulates fire emergencies, allowing users to apply the PASS method (Pull, Aim, Squeeze, Sweep) effectively.

Normal Game Training: Offers a non-VR alternative where users receive guided learning through interactive scenarios, enabling them to learn fire safety procedures without requiring VR hardware

4.5. Evaluation and Feedback System

To ensure continuous improvement, the system includes a question/answer and help mechanism that provides real-time feedback and performance evaluation. Users receive hints and guidance during training, while their actions are assessed to measure their understanding and response time in handling fire emergencies.

4.6. Accessibility and Scalability

The system is designed to be scalable and accessible, allowing organizations, schools, and safety institutions to adopt the training easily. The dual-mode training (VR and non-VR) ensures that the system caters to a wide range of users, irrespective of their access to VR hardware. By incorporating these features, the proposed system delivers a cost-effective, immersive, and interactive fire safety training solution that enhances user preparedness and response in real-life emergencies.

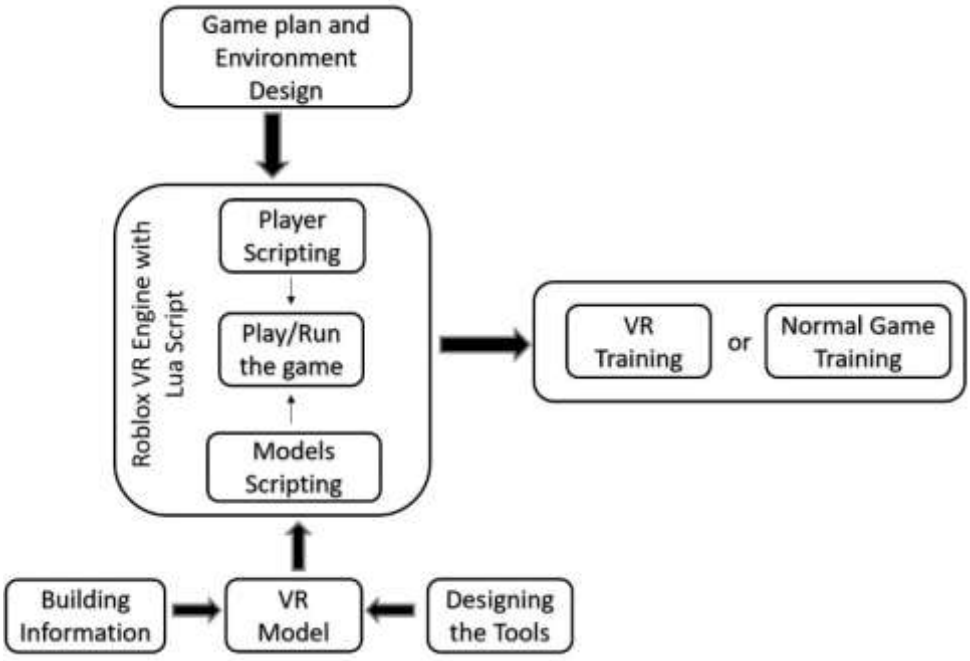

Figure 4.1: Block Diagram of VR training framework.

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5. GAME ENVIRONMENT

5.1. Environment

Figure 5.1: Environment of the School

This image represents the main environment for the fire game set in a school. The school building serves as the primary location where different fire emergency scenarios take place.

5.2. LEVEL 1

Figure 5.2: Level 1 Fire Scenario

This image represents the first level of the fire training game, set in a school computer lab, where a fire breaks out near the server racks. Players must use a fire extinguisher to put it out, learning how to handle electrical fires safely

5.3. Fire Extinguisher

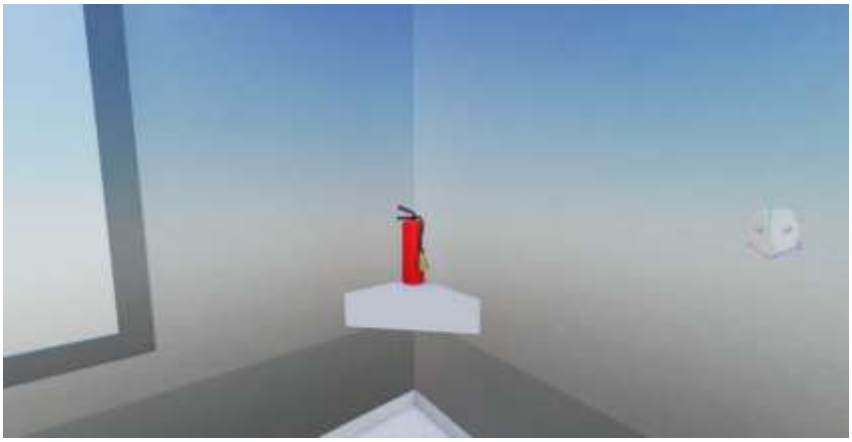

Figure 5.3: Designed Fire Extinguisher

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This image represents a fire extinguisher in the computer lab. Players must find and use it to extinguish the fire, highlighting the importance of fire safety.

5.4. Level 2

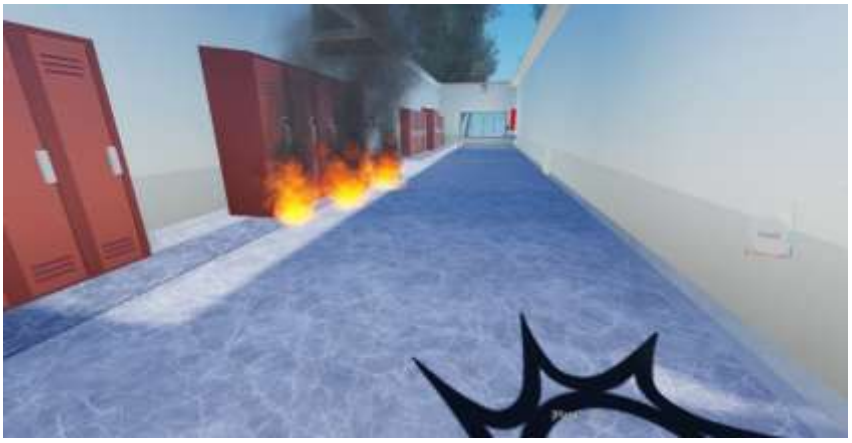

Figure 5.4: Level 2 Fire Scenario

This image represents the second level of the fire training game, set in a school, where a fire breaks out. Players must use a water hose to put it out, learning how to handle fires safely

5.5. Water Hose

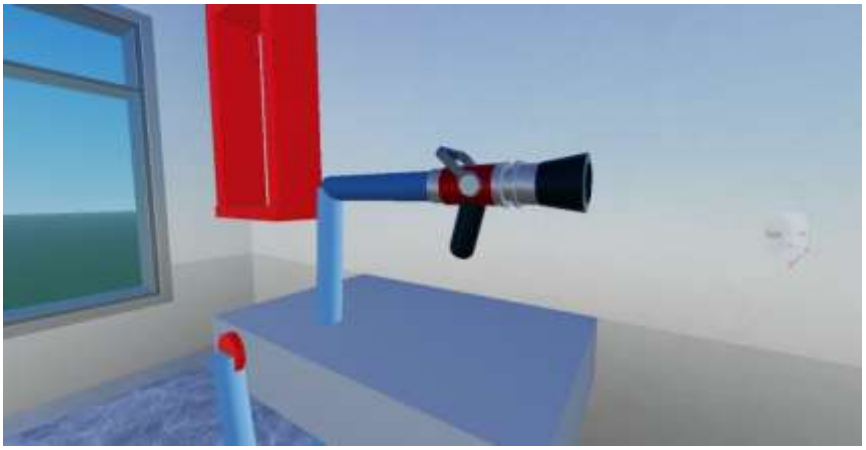

Figure 5.5: Designed Water Hose

This image represents Level 2 of the fire training game, which takes place in the corridor outside the computer lab. In this level, players must use a water hose to extinguish the fire spreading in the hallway.

6. RESULTS

6.1. Internal Survey among College Students

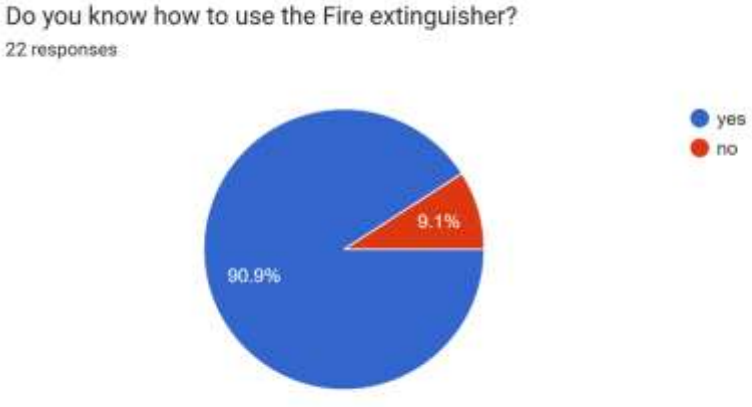

Figure 6.1.1: Knowledge of Fire Extinguisher Usage

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90.9% of students reported knowing how to use a fire extinguisher, while 9.1% did not. This suggests a high level of awareness, but further training can ensure all students gain hands-on experience. Regular fire safety drills and interactive training methods can reinforce practical skills for emergency situations.

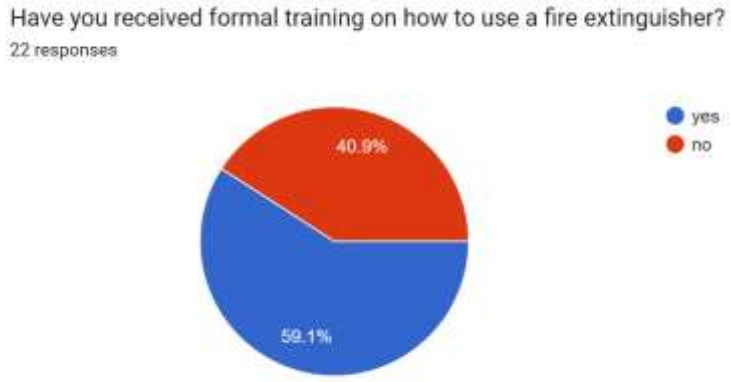

Figure 6.1.2: Fire Extinguisher Training Experience

59.1% of students have received formal fire extinguisher training, while 40.9% have not. This highlights the need for better fire safety education. Increasing hands-on training opportunities could improve preparedness and response skills, ensuring more students gain essential knowledge on handling fire emergencies effectively and confidently.

Figure 6.1.3: Training Preference: Traditional vs. VR

72.7% of students preferred VR-based fire extinguisher training over traditional classroom or hands-on methods. This indicates a shift toward interactive and immersive learning approaches. VR training can provide realistic fire emergency scenarios, allowing students to practice without real risks while enhancing engagement, confidence, and retention of safety procedures.

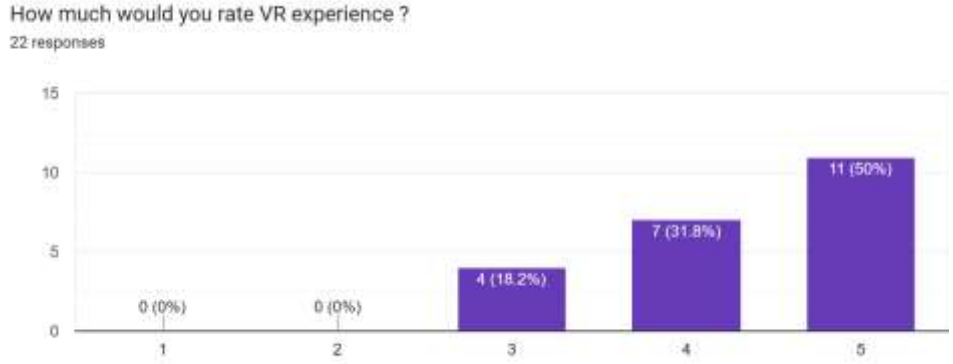

Figure 6.1.4: VR Training Experience Rating

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81.8% of students rated their VR fire extinguisher training experience as 4 or 5, with no ratings below 3. This demonstrates high satisfaction and effectiveness. VR-based training provides a hands-on, engaging approach that enhances learning and retention, making it a promising alternative to traditional fire safety training methods.

6.2. External Pre-VR Training Survey Results among School Students

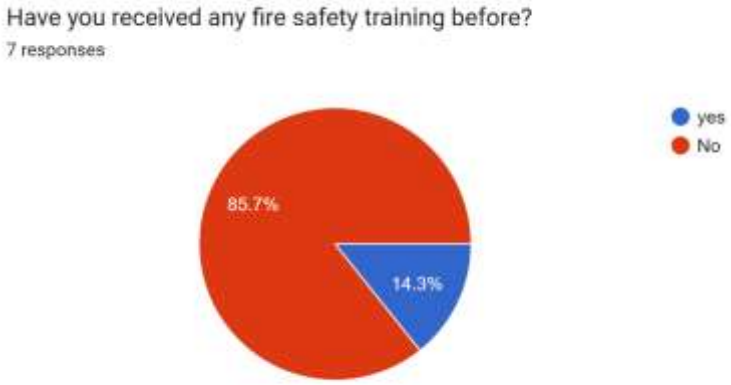

Figure 6.2.1: Prior Fire Safety Training

The survey shows 85.7% of students had no prior fire safety training, while only 14.3% received training. This highlights a significant gap in preparedness, emphasizing the need for structured training programs like VR simulations to enhance safety awareness.

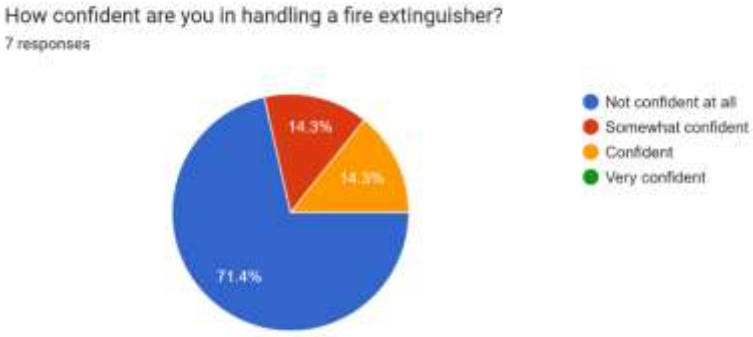

Figure 6.2.2: Confidence in Handling a Fire Extinguisher

71.4% of students feel confident using a fire extinguisher, while 14.3% are somewhat confident, and another 14.3% are not confident at all. The results suggest that while most are confident, practical training could further improve skills and assurance.

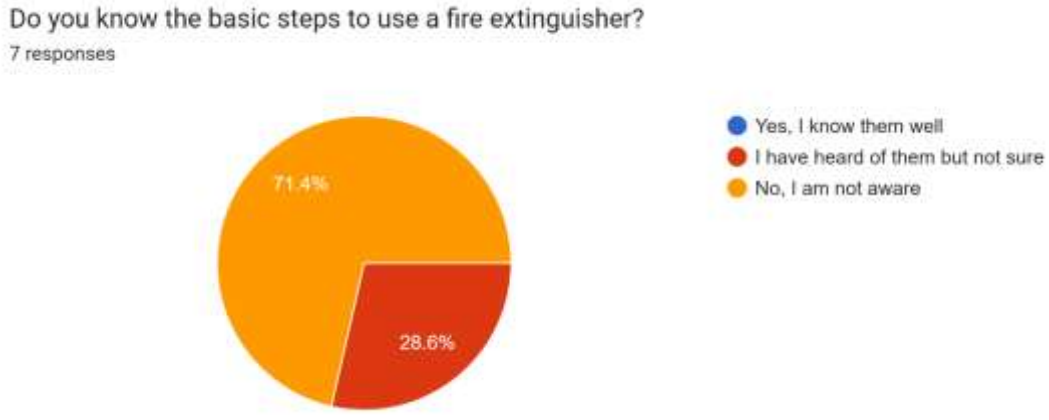

Figure 6.2.3: Awareness of Fire Extinguisher Steps

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71.4% of students know the basic steps to use a fire extinguisher well, while 28.6% are unsure. This indicates a majority have theoretical knowledge, but hands-on practice (like VR training) could reinforce learning for those less familiar.

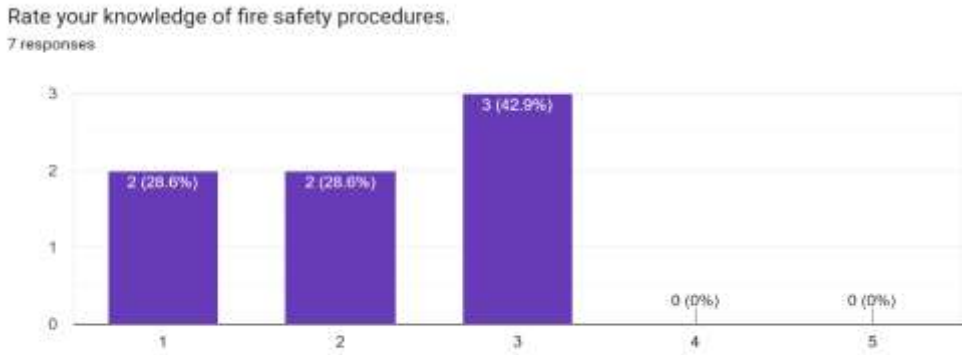

Figure 8.2.4: Knowledge of Fire Safety Procedures

42.9% rated their fire safety knowledge as "3" (moderate), while 28.6% rated it "2" (low). None rated it "1" or "0," suggesting basic awareness exists, but deeper training is needed to improve competency levels.

6.3. External Post-VR Training Survey Results among School Students

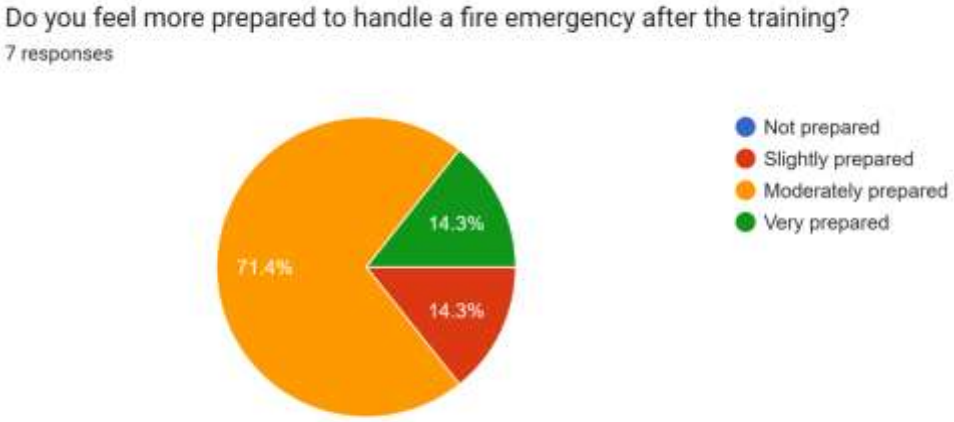

Figure 6.3.1: Preparedness for Fire Emergencies After VR Training

After VR training, 85.7% of students felt at least moderately prepared for fire emergencies (57.1% moderately, 28.6% very prepared), while 14.3% remained slightly prepared. The training significantly boosted emergency readiness compared to pre-VR survey results.

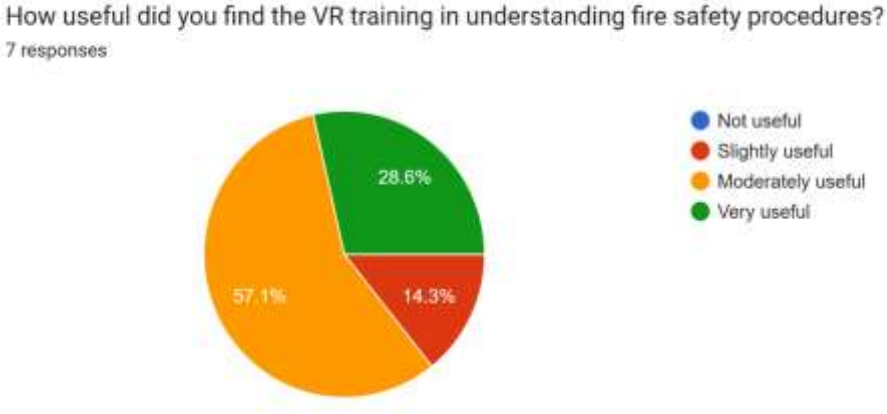

Figure 6.3.2: Usefulness of VR Training for Fire Safety Understanding

85.7% of students found the VR training useful (57.1% moderately useful, 28.6% very useful), while 14.3% deemed it slightly useful. The high usefulness rating underscores VR's effectiveness in teaching fire safety procedures.

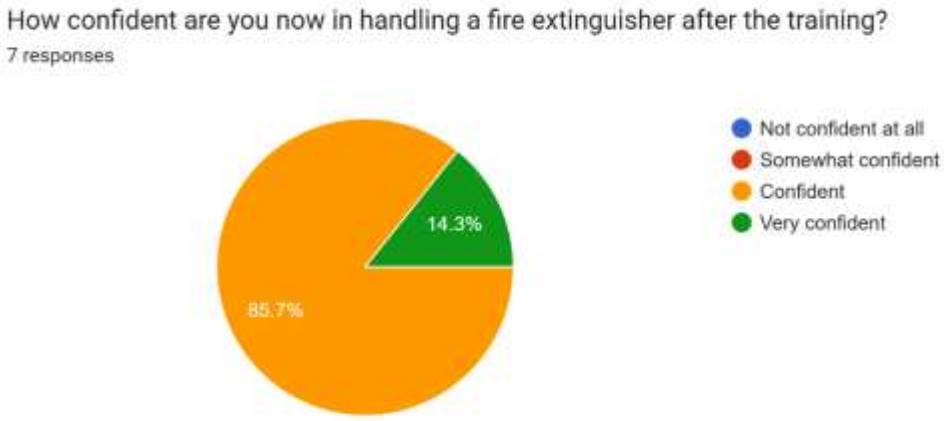

Figure 6.3.3: Confidence in Handling Fire Extinguishers Post-Training

VR training dramatically improved confidence: **85.7%** of students reported being confident or very confident in handling extinguishers, compared to **71.4%** pre-training. Only **14.3%** remained somewhat confident, with none unconfident.

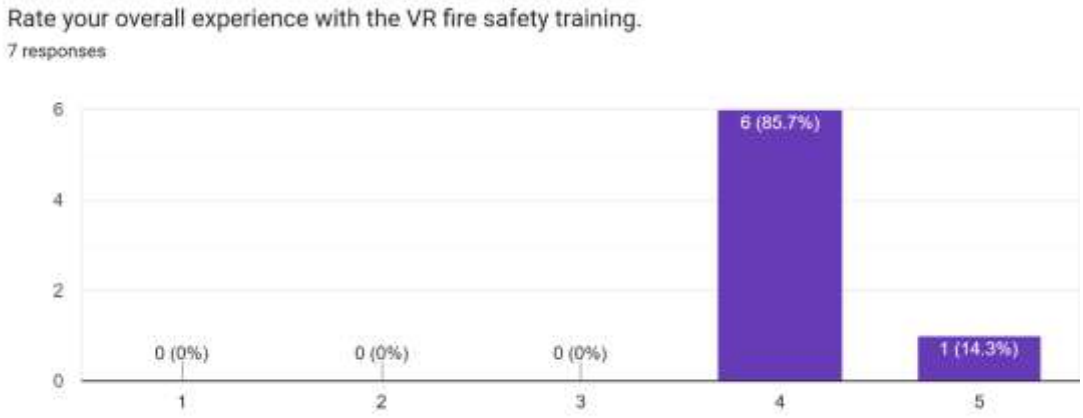

Figure 6.3.4: Overall Satisfaction with VR Fire Safety Training

85.7% of students rated their VR experience highly (top ratings: 5–6), while **14.3%** gave a neutral score (4). No negative feedback was recorded, highlighting strong engagement and satisfaction with the training.

7. CONCLUSION

Flame Guard VR represents a significant advancement in fire safety training by leveraging virtual reality to create an engaging and hands-on learning experience. Unlike traditional fire safety training methods, Flame Guard VR allows participants to practice handling different types of fires, refine their extinguisher skills, and respond to emergency scenarios in a fully immersive environment. The integration of artificial intelligence for real-time feedback and customized learning ensures that each user receives personalized instruction, enabling them to acquire skills at their own pace and build their confidence.

With features that facilitate collaborative training and cloud-based access for remote and large-scale use, Flame Guard VR makes comprehensive fire extinguisher training both efficient and flexible. By merging realistic simulations with easy accessibility, this application empowers workplaces, educational institutions, and communities to uphold high safety standards while minimizing the costs and risks associated with conventional training methods. Ultimately, Flame Guard VR fosters a culture of preparedness, equipping users with the essential skills and knowledge to respond effectively in any fire emergency, thus establishing itself as an essential tool in modern fire safety education.

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