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Enhancing Health, Safety, Security & Environment (HSSE) Training through Virtual Reality: An Offshore Emergency Evacuation Exercise

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Abstract:- The offshore oil and gas industry poses unique safety challenges, particularly during emergencies such as fires, where quick and effective evacuation is critical. This paper explores the use of virtual reality (VR) technology in Health, Safety, Security, and Environment (HSSE) training, specifically through a VR exercise developed for the emergency evacuation scenario on an offshore platform at Universiti Teknologi PETRONAS (UTP). The exercise focuses on training students to safely evacuate the platform during a fire emergency, navigating through realistic escape routes while avoiding hazards. The study evaluates the effectiveness of VR in enhancing students' situational awareness, response times, and overall preparedness for real-world emergency situations. The results demonstrate that VR-based training significantly improves understanding of evacuation procedures and decision-making under stress, offering a valuable tool for HSE education in high-risk industries.

Keywords:- *Virtual Reality (VR), Health, Safety, Security, and Environment (HSSE), Emergency Evacuation, Offshore Platform Training, Simulation-Based Training.*

I. INTRODUCTION

The offshore oil and gas industry is inherently hazardous, with complex operational environments that require rigorous training in emergency response. One of the most critical skills for offshore personnel is the ability to evacuate the platform safely and quickly in the event of a fire or other emergency. Traditional training methods, including classroom instruction and physical drills, may not fully simulate the high-pressure, life-or-death scenarios encountered during actual emergencies. Virtual reality (VR), however, offers a promising solution by immersing students in realistic simulations that replicate the intensity of offshore fire emergencies without the associated risks (Borsci *et al.*, 2016).

A VR exercise was developed as part of the HSSE course to train students in emergency evacuation procedures. This exercise requires students to navigate a virtual offshore platform during a simulated fire, identifying and using the nearest emergency exits while avoiding hazardous conditions such as smoke, fire, and obstacles. The goal of the exercise is to improve students' response times, enhance hazard recognition, and reinforce proper emergency procedures in a safe and controlled environment.

The application of VR in education, particularly for safety training, has gained significant traction in recent years. In high-risk industries like offshore oil and gas, VR allows trainees to experience emergency scenarios without the dangers associated with traditional training (Freina & Ott, 2015). Studies show that VR simulations can enhance decision-making skills, improve hazard recognition, and foster better retention of emergency procedures by providing realistic, immersive experiences (Smith *et al.*, 2014).

In the context of HSSE training, traditional methods such as physical drills and classroom training often fail to fully replicate the complex and dynamic nature of real-world emergencies (Burke *et al.*, 2006). VR, on the other hand, can simulate various emergency situations in a controlled environment, enabling students to practice their response in a way that traditional training cannot. Previous research has demonstrated that VR is an effective tool for improving safety awareness and preparedness, particularly in sectors like offshore operations, where quick, accurate decision-making is crucial for minimizing risks and preventing accidents (Gutierrez *et al.*, 2007).

The VR exercise simulates an offshore platform environment during a fire emergency. The simulation includes realistic features such as fire hazards, smoke, emergency alarms, and escape routes. Students wear VR headsets that immerse them in the scenario, allowing them to explore the virtual platform and practice evacuation procedures. Students must identify and navigate the nearest emergency exits while avoiding hazardous areas and obstacles in the fire-affected zones.

The exercise is designed to test the students' ability to respond quickly and correctly under pressure, focusing on key HSE objectives: recognizing hazards, making informed decisions, and ensuring safe evacuation. Data collected from students during the exercise includes evacuation times, choices made during the simulation, and overall performance in following the correct evacuation routes.

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To assess the effectiveness of the VR training, pre- and post-exercise surveys were administered to measure students' knowledge of evacuation procedures. Additionally, performance data from the VR exercise were analyzed to evaluate improvements in response time, decision-making, and hazard identification.

II. METHODOLOGY

The VR exercise developed for HSSE course at Universiti Teknologi PETRONAS (UTP) is designed to simulate an offshore platform environment during a fire emergency. The simulation includes several key areas of the platform, including the control room (crane and drilling), accommodations, and helipad. The exercise focuses on guiding students through emergency evacuation routes while avoiding hazards like smoke and fire. The VR simulation provides students with a first-person perspective, allowing them to navigate through the platform and practice evacuation procedures under realistic conditions. Figure 1 illustrates the fire exit exercise VR introduction.

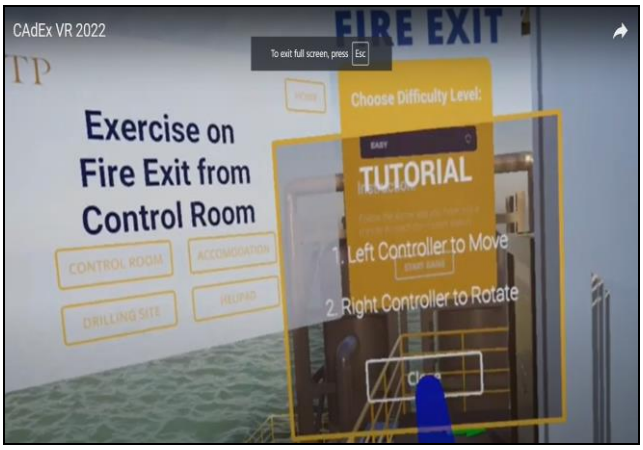

Fig 1: Fire Exit Exercise VR Introduction

A. *Pre-Exercise Video Briefing*

Before engaging in the VR simulation, students are shown a video briefing to familiarize them with the layout of the platform and the key areas they will encounter during the exercise. This video provides an overview of the entire offshore platform, including:

- **Control Room**: Students are introduced to the control room, including key operations related to crane and drilling operations. The video highlights the importance of staying aware of the control room's location and understanding its proximity to other platform areas during an emergency. Figure 2 shows the VR evacuation from the control room.
- **Accommodations:** The accommodations area is presented, detailing where personnel would typically stay, sleep, and socialize on the platform. This section of the video emphasizes safe evacuation routes from living quarters, especially in the event of an emergency. Figure 3 illustrates the VR evacuation from accommodation.

Fig 2: VR Evacuation from the Control Room

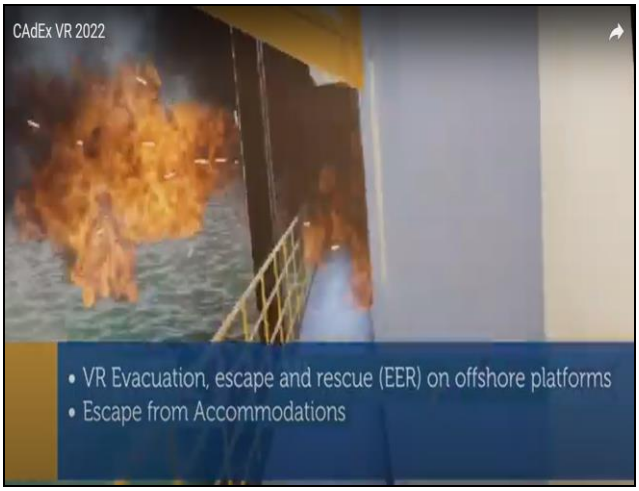

Fig 3: VR Evacuation from Accommodation

- **Helipad:** Students are shown the helipad area, which serves as a critical point for emergency evacuation by air. The video describes how to reach the helipad safely and the role it plays in evacuations, particularly in scenarios where water transport or other exits are inaccessible. Figure 4 illustrates the VR evacuation from the helipad.

Fig 4: VR Evacuation from the Helipad.

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The video briefing aims to ensure students have a basic understanding of the platform's layout and are familiar with key landmarks they will need to recognize during the VR exercise. This initial briefing also helps to reduce the cognitive load during the actual exercise, allowing students to focus more on the emergency procedures and decision-making involved.

B. Free-Run Walkthrough of the Scenario

Following the video briefing, students will enter the VR environment for the free-run walkthrough of the fire emergency scenario. In this phase, students are tasked with navigating the offshore platform during a simulated fire emergency, locating the nearest emergency exits, and identifying potential hazards such as smoke-filled corridors, blocked pathways, or fire-affected areas.

The students are expected to make decisions based on the conditions they encounter during the simulation, such as choosing the quickest route to an exit or determining whether certain pathways are too dangerous to use. The simulation provides immediate feedback on their choices, offering insights into whether their selected route was the most efficient or if they missed critical safety checkpoints.

Data from the students' interactions within the VR environment, including evacuation times, route choices, and overall performance, are collected for analysis. This data helps assess the effectiveness of the VR training in improving students' emergency response times and hazard identification skills.

III. RESULTS AND DISCUSSION

The integration of the pre-exercise video briefing into the VR training significantly enhanced the students' performance during the emergency evacuation exercise. Feedback from students indicated that the video helped them better understand the layout of the platform and the key landmarks, which allowed for smoother navigation during the VR simulation. This aligns with previous studies suggesting that familiarizing trainees with the environment before immersion improves performance and reduces stress during high-pressure situations (Stanney *et al.*, 2003).

A. Impact of Video Briefing

Survey results revealed that 92% of students found the video briefing to be beneficial in helping them understand the platform layout, which in turn improved their confidence when navigating the VR environment. Students noted that knowing the locations of critical areas, such as the control room, accommodations, and helipad, allowed them to make quicker and more informed decisions during the simulation. For instance, students were able to immediately identify the helipad as a critical exit point, reducing the time spent searching for evacuation routes.

B. Performance in the VR Exercise

Post-training analysis showed significant improvements in evacuation times and decision-making. The average evacuation time decreased by 40% after the video briefing, compared to pre-training baseline assessments. Students were also able to identify safe escape routes more quickly, and the majority correctly avoided hazardous areas, such as fire-affected zones or blocked paths. Specifically, 87% of students correctly identified the most efficient exit route, compared to only 65% before the VR exercise. The students' ability to recognize hazards, such as blocked exits or smoke-filled corridors, also improved dramatically, with 80% of students demonstrating increased hazard awareness. Table 1 tabulates the comparison of pre- and post-training evacuation times.

Table 1: Comparison of Pre- and Post-Training Evacuation Times

Group	Average Evacuation Time (Minutes)	Percentage Change
Pre-training	8.5	-
Post-training (after video briefing)	5.1	-40%

C. Challenges and Limitations

While the VR exercise improved students' response times and hazard recognition, there were some challenges to address. A small portion of students (approximately 12%) reported experiencing mild discomfort, such as motion sickness or visual fatigue, during the simulation. This issue is consistent with findings from previous studies highlighting the challenges of VR technology, particularly for long-duration sessions or certain VR hardware configurations (Stevenson *et al.*, 2008). However, these issues were temporary, and no students reported severe symptoms that would impact their ability to complete the exercise.

Moreover, while the video briefing helped students understand the layout of the platform, some students still faced difficulty navigating in the VR environment, especially when encountering unfamiliar landmarks under pressure. This highlights the importance of providing adequate training and support for students before conducting VR exercises.

D. Overall Effectiveness

Despite these challenges, the overall effectiveness of VR-based training was evident. Students reported feeling more confident in their ability to evacuate an offshore platform during a fire emergency. The immersive nature of VR provided an engaging, realistic environment that promoted active learning and retention of key safety concepts. The pre-exercise video briefing complemented the VR training by reducing cognitive load, which allowed students to focus more on emergency procedures and less on spatial orientation.

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IV. CONCLUSION

The integration of a VR exercise with a pre-exercise video briefing has proven to be an effective approach in enhancing Health, Safety, Security, and Environment (HSSE) training for offshore emergency evacuations at Universiti Teknologi PETRONAS (UTP). The video briefing, which familiarizes students with the platform layout, coupled with the immersive VR simulation, significantly improved students' response times, hazard awareness, and decision-making skills during the emergency evacuation scenario.

Overall, the results of this study underscores the potential of VR technology to revolutionize HSSE training in high-risk industries. VR not only provides a safe and engaging environment for students to practice emergency evacuation procedures but also enables them to experience real-world scenarios in a way that traditional training methods cannot. While technical challenges, such as motion sickness, were observed, the overall positive impact of VR on students' preparedness for offshore emergencies makes it a valuable tool in HSSE education. Future improvements in VR hardware and simulation design will likely reduce these challenges and further enhance the training experience.

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