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Disaster Prep: Development of Virtual Reality Application for Natural Disaster Preparedness and Response

Hadzilhareeq Hairizan[1], Norhanifah Murli[1]*

[1] *Faculty of Computer Science and Information Technology, Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, 86400, MALAYSIA*

*Corresponding Author: hanifah@uthm.edu.my
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Abstract

Natural disasters such as floods, fires, and storms continue to pose serious threats to safety and infrastructure. In Malaysia, changing weather patterns have increased the frequency of such events, often catching unprepared residents off guard. This project introduces Disaster Prep, a virtual reality (VR) application designed to educate users on disaster preparedness through immersive simulation. Developed using Unity and based on the TRES-D methodology, the application features four modules: Ready-To-Go (RTG) bag preparation, fire response, flood response and storm sheltering. The target users are the general public aged 12 and above. Input from a Malaysian Civil Defense Force expert was incorporated to ensure realism and accuracy. Functional and user acceptance testing were conducted, with the System Usability Scale (SUS) producing an average score of 71.75, placing it in the "acceptable" range with a "Good" rating. The results show that Disaster Prep effectively supports disaster education by delivering engaging, realistic scenarios that increase awareness and preparedness. By offering interactive training in a safe virtual environment, the app aims to improve users' decision-making and readiness during emergencies besides offering a scalable and modern solution for public safety training.

1. Introduction

Virtual Technology (VR) technology has been a core idea in the development of technology that goes hand in hand with the advancement of Artificial Intelligence (AI). These have been the forefront of the IR 4.0 in hopes of integrating tech into our daily life. With the further development of tech in recent years, VR devices has become more affordable for the public.

In recent years, Malaysia has experienced changes in the weather that causes location that does not usually experience flood notice the water level raising[1]. Inexperienced residents had a hard time navigating the situation as they had not prepared for it. Disasters, including fires, floods, and storms, cause significant damage to lives, economies, and infrastructure worldwide, emphasizing the importance of disaster preparedness and education. However, traditional methods of disaster education, such as textbooks and videos, often lack interactive and engaging components, leading to low user retention and understanding. While physical drills can be effective, they are expensive and logistically challenging to organize[2]. VR technology offers a modern and innovative solution by simulating realistic disaster scenarios, providing users with immersive and interactive learning experiences[3]. This can help the residents retain all the information taught by instructors.

Despite the potential of VR in disaster preparedness, existing solutions are limited in their scope and practicality. Applications like Solferino Academy's Disaster Preparedness VR focus on general disaster awareness for younger audiences but lack interactive decision-making elements[4]. Similarly, Flood Action VR specializes in flood preparedness but does not address other disasters such as fires or storms[5]. Disaster Prep, the developed VR application, aims to bridge these gaps by offering simulations for multiple scenarios, including floods, fires, and storms, with interactive elements.

The objectives of this project are to design Disaster Prep based on 3D approach, to develop Disaster Prep application through virtual reality approach, and to conduct functional and user acceptance testing on the developed application with the target user. The primary target audience for this application is public users aged 12 and above. The application's focus is on providing a hands-on experience that guides users how to respond through realistic disaster situations, enhancing their preparedness and response capabilities. The subject matter expert (SME) participating in this project is Kapt. (PA) Mohd Aziz Bin Jupri, a Malaysian Civil Defense Force personal stationed at Batu Pahat.

The Disaster Prep application is developed using Unity to create a 3D environment that simulate natural disaster happening at home. The app contains four modules: Ready To Go (RTG) bag preparation, Fire, Storm, and Flood preparation and simulation. The application allows the user to be immersed when preparing the RTG bag, besides experiencing putting out fire in a safe environment and sheltering during a thunderstorm.

The rest of the paper is arranged as follows: Section 2 covers the domain background, VR technology and comparative analysis of existing applications. Section 3 explains the TRES-D (ThREe-dimensional uSer interface Development) methodology that is used to develop the project as well as the results of the phases. Section 4 explains the result and discussion of the project. Lastly, section 5 provides the conclusion of the current progress.

2. Related Works

This section includes the domain background, VR technology, study of existing applications and the comparative analysis.

2.1 Disasters

A disaster is a sudden and often unexpected event that causes significant damage, disruption, or even loss of life. Disasters can be broadly categorized into two main types: natural disasters and man-made disasters. In Malaysia, natural disasters are quite common due to its geographical and climatic conditions. Some of the most frequently occurring natural disasters include floods, hurricanes, and landslides[6]. These events can happen with little warning and vary greatly in terms of severity, depending on factors such as the location, time of year, and level of preparedness of the affected community.

Floods are one of the most common disasters in Malaysia, especially during the monsoon season[7]. Low-lying areas are particularly vulnerable, and severe flooding can displace families, destroy property, and disrupt transportation and communication systems. Hurricanes, though less frequent, can bring heavy rain and strong winds, causing widespread damage[8].

On the other hand, man-made disasters in Malaysia include fires, industrial accidents, and transportation-related incidents such as train or road accidents[9]. These often result from human error, negligence, or equipment failure.

Although most disasters cannot be fully prevented, being prepared can significantly reduce their impact. It is crucial for Malaysians to increase awareness and readiness, especially for recurring disasters like floods, hurricanes, and fires. Unfortunately, even though these disasters occur frequently, the general public still lacks sufficient preparedness and knowledge on how to respond effectively when they happen. Enhancing disaster education and emergency response training can play a vital role in minimizing casualties and damage in future incidents[10].

2.2 Virtual Reality Technology

Virtual Reality (VR) technology has emerged as a transformative tool in digital interaction, offering users immersive experiences that extend far beyond traditional screen-based media[11]. At its core, VR places users inside a computer-generated environment where they can explore, engage, and respond as if they were physically present. However, not all VR is created equal. There are different types of VR experiences, each suited to specific purposes and levels of immersion.

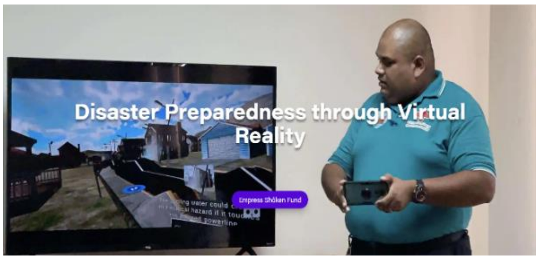
The most immersive form is Fully Immersive VR, which requires devices such as head-mounted displays, motion sensors, and sometimes haptic feedback equipment. This type allows users to move within a 3D space and interact naturally with the environment. It is particularly effective for training scenarios that simulate real-world conditions, making it ideal for applications involving high-stakes or emergency situations, where real-life practice may be too dangerous or impractical. Semi-Immersive VR strikes a balance between realism and accessibility. Often used in simulation-based training, such as flight simulators or architectural walkthroughs, this type of VR typically uses large screens or projections to display virtual environments, without requiring full-body tracking or headsets. Though less immersive, it still provides users with a strong sense of presence and spatial awareness. Non-Immersive VR, on the other hand, refers to traditional screen-based interaction, such as using a computer to navigate a virtual environment with a mouse and keyboard. While it does not fully immerse the user, it remains useful for learning purposes, especially in environments where high-end hardware is unavailable. There is also Augmented VR or Mixed Reality (MR), where virtual elements are overlaid onto the physical world. While not purely VR, this hybrid approach is gaining traction for real-time interaction and training.

Understanding the different types of VR is crucial when designing experiences tailored to specific goals. For instance, in the context of safety and disaster preparedness, fully immersive VR allows users to navigate high-pressure situations, like floods, fires, or storms, making decisions in real time and learning from the outcome in a controlled, repeatable way[12]. By selecting the right type of VR, developers can maximize both impact and accessibility, ensuring the technology is effective for a wide range of users and settings.

2.3 Comparative Analysis

The following compares the features, strengths, and limitations of existing virtual reality applications for disaster preparedness with the developed Disaster Prep application. Key characteristics evaluated include the range of scenarios covered, interactivity, target audience, technology platform, visual fidelity, audio integration, and learning objectives. Figure 1 shows the examples of the existing application.

(a)



(b)

(c)

Fig. 1 *(a) University of Michigan's VR Simulations[3] (b) Solferino Academy's Disaster Preparedness VR [4] (c) ; Flood Action VR[5];*

Table 1 *Comparison between existing applications and the developed application*

Features	Solferino Academy's Disaster Preparedness VR	University of Michigan's VR Simulations	Flood Action VR	Disaster Prep
Scenarios Covered	Hurricanes, flood	Earthquakes, hurricanes	Flood	Flood, fire, storm
Interactivity	Minimal	Normal	High interactivity	High interactivity
Target Audience	Younger audiences	Professionals, city planners	Disaster response professionals	General public

Table 1 *Comparison between existing applications and the developed application (Continued)*

Visual Fidelity	Low	Medium	High	High
Audio Integration	Basic sound effects	Immersive audio	Immersive audio	Immersive audio
Learning Objectives	Basic disaster awareness	Urban planning and disaster response	Flood preparedness	Multi-disaster preparedness and response
Strengths	Easy for beginners	Effective for urban scenarios	Highly focused on floods	Multi-disaster coverage
Limitations	Lacks hands-on decision-making; limited to visualization	Urban focus; excludes floods, fires, and other scenarios	Narrow scope; limited to flood preparedness	Focused on exhibition-based training

By analyzing these aspects, Table 1 highlights how Disaster Prep addresses the gaps in existing solutions, offering a more comprehensive and practical training tool for emergency response teams and the public. Solferino Academy's VR focuses on general disaster awareness with minimal interaction, making it suitable for younger audiences, but it lacks specific disaster scenarios[4]. University of Michigan's VR targets professionals and city planners with urban disaster simulations like earthquakes and hurricanes, offering medium visual fidelity and immersive audio[3]. Flood Action VR is highly interactive and visually detailed, but it specializes solely in flood scenarios for disaster response professionals[5]. In comparison, Disaster Prep covers a broader range of scenarios, such as floods, fires, and storms, targeting both emergency teams and the public. While its interactivity, visuals, and audio are not as advanced as some apps, it offers a versatile and accessible training experience using the Meta Quest VR headset.

3. TRES-D Methodology

Disaster Prep is a virtual reality application that focuses on preparation against disasters. Thus, the only suitable methodology for the development of the application, TRES-D (ThREe dimensional uSer interface Development) methodology [13] was chosen.

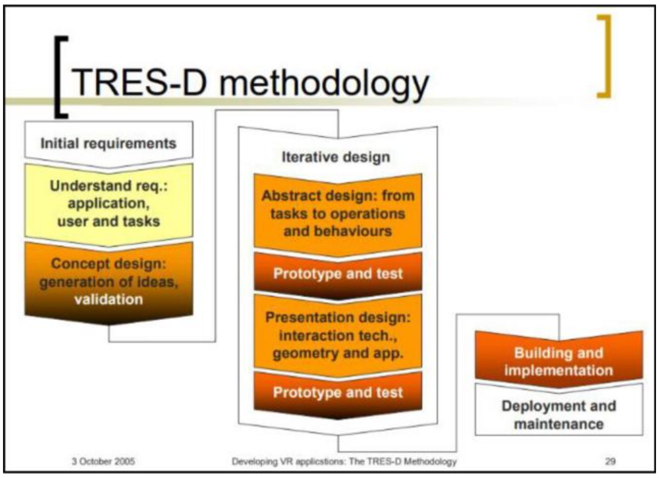


Fig. 2 *TRES-D Methodology [13]*

3.1 Initial Requirement Phase

In this phase, the application initial requirement checklist had been created as shown in the Table 2 below. Besides that, this phase discussed and determined the initial requirement of the application like the objective, problem statement, expected outcome, and project significance. The information required before the design and development of the Disaster Prep was determined.

Table 2 *Initial requirement checklist*

Item	Description
Type of application	Virtual Reality Application
Target device	PC based VR platform
Target user	Users aged 12 and above
Content	Disaster preparation and simulation
3D model	Detailed 3D model of the item for the disaster preparation, and house for the simulation
Application synopsis	Disaster Prep is a VR application developed to guide the general public on disaster preparation while experiencing an immersive disaster experience. The application covers 3 major disaster that often occurs in Malaysia such as Flood, Fire, and Storm. The application aims to educate users through experience on how to prepare for disasters.

3.2 Understand Requirements

In this phase, an analysis was conducted by gathering all the information needed for developing a virtual experience of disaster and preparation against it. The developed application was briefly explained, and the problem statement was defined properly. The objectives to reach the goal had also been determined and the key scenario list are shown in Table 3. The result of the user analysis is tabulated in Table 4.

Table 3 *Key Scenario List*

Subject Matter Expert Aspect	Key Scenario
Disaster Preparation	• Complete the disaster specific preparation before experiencing the disaster simulation such as flood, fire and storm.
User Interaction	• Interact with virtual objects like fire extinguishers and RTG bag
Disaster Experience	• Engage in disasters simulation in a virtual environment
Multisensory Experience	• Immerse in background noise that simulate specific disasters

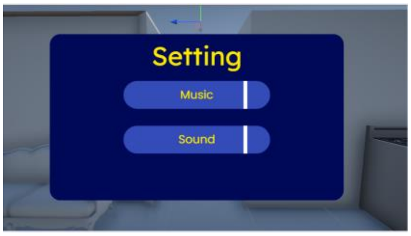
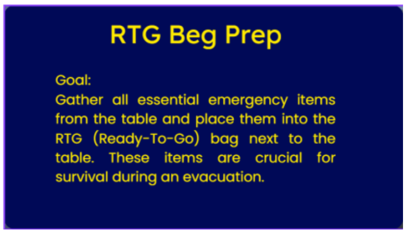
Table 4 *User requirement Analysis*

User preferences	Description
Interested aspects	• Experiencing disasters in a VR application • Preparing for disasters in VR application
Features	• Immersive disaster simulation with sound effects • Guidance for disaster preparation
Multimedia Elements	• 3D model • Graphic or image
Type of Navigation	• Menu-based navigation

3.3 Concept Design

The goal of this phase is to identify the functional task that the user will be able to do with the application, as well as the hardware and software requirement. A storyboard has been created to provide a visualization of the Disaster Prep application as shown in Table 5.

Table 5 *Storyboard*

Item	Description
	• This is main menu interface • Consist of module selection between RTG bag prep, Flood, Fire and Storm.
	• This is setting interface • User can increase or decrease the sound and music during the gameplay
	• This is the instruction interface that will provide a brief explanation on the goal of each module • User can proceed to the module by tapping the interface
	• This is the RTG bag prep module. • User can pick up each item and put it in the designated spot in the RTG bag.

The functional requirement and non-functional requirement are tabulated in Table 6 and Table 7 respectively.

Table 6 *Functional requirement*

Functional requirements	Module	Description
Autonomous system activities	RTG bag preparation	• The user should be able to see the information details of the items when they are pointed out
	Disaster Preparation	• User can select and run 3 disaster such as Flood, Fire, and Storm. • Each disaster includes interactive VR mechanics that simulate the real-world experience
	Audio	• The environment should have sound effects that simulate each disaster.

Table 6 *Functional requirement (Continued)*

User interaction support	Main Interface	• The application should allow users to click on the start button to start the application.
	Main Menu	• The application should allow users to select an activity by clicking on the labelled buttons.
	Disaster Preparation Module	• Application should allow users to experience preparing for a disaster and going through the disaster safely. • The application allows users to click on interactive elements within the application to learn more about disaster preparation

Table 6 outline the Disaster Prep's functional requirements, including modules for disaster preparation, RTG bag preparation and audio for seamless experience.

Table 7 *Nonfunctional requirement*

Nonfunctional Requirements	Description
Performance	• The application should not be lag and provide a smooth VR interaction. • Loading times for modules and game should not exceed 5 seconds.
Usability	• Instructions should be simple and engaging. • Clear indicators and simple controls.
Accessibility	• Including customizable settings such as content language, sensitivity, and control types.
Compatibility	• Application must be compatible with standard VR hardware such as meta quest 3

Table 7 shows the non-functional requirements including performance, usability, accessibility and compatibility aiming for smooth performance, engaging experiences and customizable settings. The hardware requirements for the user are shown in Table 8 while the hardware and software requirements for the developer are shown in Table 9.

Table 8 *User Hardware Requirements*

Requirements	Item	Description
Hardware	Computer	Allow users to install and launch the application. Minimum specifications requirements are as follows: • Operating System: Windows 10(minimum) • Processer: Multi-Core Processor • Graphics: NVIDIA GeForce RTX Series (Recommended) • Installed Memory (RAM): 8.00GB • Storage: Sufficient storage space for download application
	VR Headset	Allow users to explore the VR environment. • RAM: 4GB and above • Storage: 64GB and above • Video output: DisplayPort 1.2 or newer • Operating system: Windows 10 or above • USB port: 1x USB 3.0 or newer

Table 9 *Developer Hardware and Software Requirements*

Requirements	Item	Description
Hardware	Laptop (ROG Strix G512LU)	Allow the developer to use software to develop and test the application . ● Operating System: Windows 11 ● Processer: 10th Gen Intel® CoreTM i7-10750H@2.60GHz ● Graphics: NVIDIA GeForce GTX1660 Ti ● Installed Memory (RAM): 16.00GB ● Storage: 594GB SSD
	VR Headset	Allow users to explore the VR environment. • RAM: 4GB and above • Storage: 64GB and above • Video output: DisplayPort 1.2 or newer • Operating system: Windows 10 or above • USB port: 1x USB 3.0 or newer
Software	Input-Output devices	Devices including mouse, keyboard and headphone for communicating with the computer
	Canva	To design the storyboard
	Blender	To create the 3D model
	Unity	To integrate the 3D models
	Visual Studio 2022	To write the C# scripts for the application

Table 8 and Table 9 outline the essential hardware requirements for both users and the developers to ensure smooth operation and development of the application. These requirements ensure that users experience the full immersion and the developer have the tools to create the applications efficiently.

3.4 Iterative Design

During the iterative design phase, the chosen solution undergoes an in-depth design process of two level, abstract and presentation.

3.4.1 Abstract Design

The concept design for the virtual world is created thus identifying the immersive navigation paths. System flowchart and navigation structure are used in this phase. Figure 3 shows the navigation structures that outline the user's path through the system, while Figure 4 shows the system flowchart that illustrates the processes and interaction within the system.

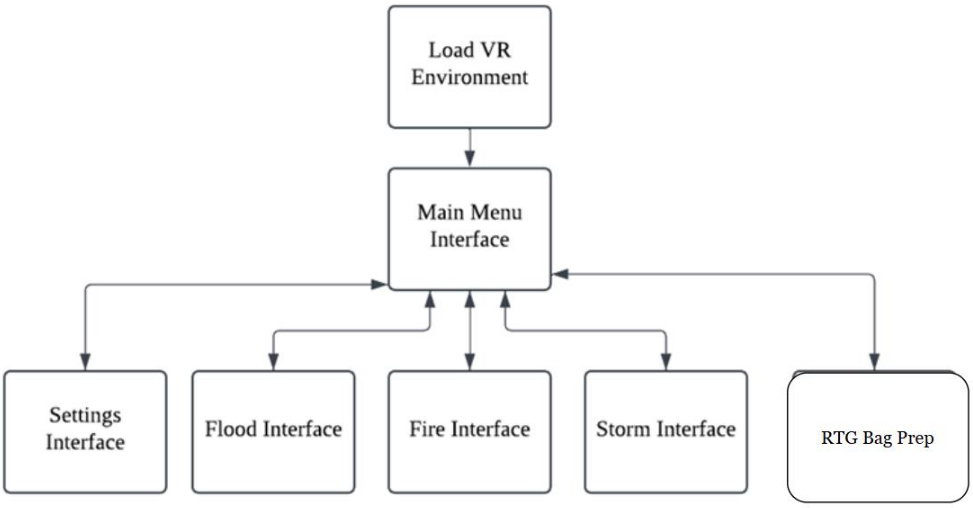


Fig. 3 *Navigation Structure*

Figure 3 shows the application will start off from the main menu in a 3D environment. The main menu consists of settings and module selection. Users can select which module to run, such as RTG bag prep, Flood, Fire, or Storm.

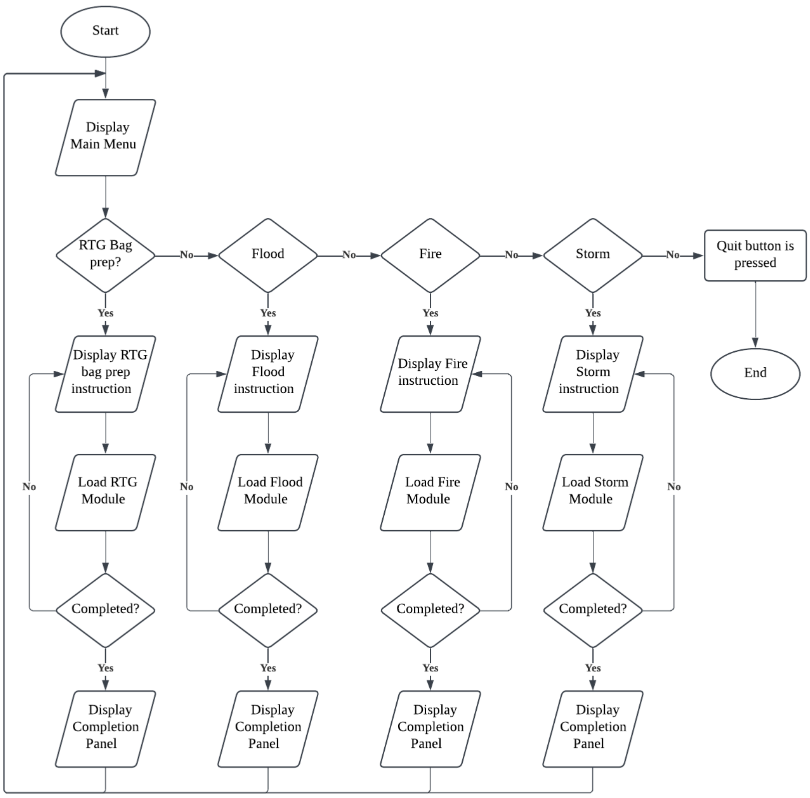


Fig. 4 *System Flowchart*

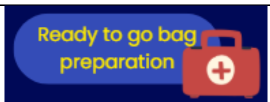
3.4.2 Presentation Design

The concept design process includes detailed low-level dialogue, and basic tasks, while gathering reference material from real world models to be integrated into the virtual world of the system interface. Table 10 shows the task that will be completed in this phase. Meanwhile, Table 11 shows the button design.

Table 10 *Task details in Presentation Design*

Tasks	Description
Selecting Interaction Styles	• Using input device when interacting with virtual objects
Basic Interaction Tasks	• Users can interact with virtual objects by using device controllers to perform the activities
Concrete Interaction Techniques	• The application will use device controllers to let user interact with the objects in the virtual environment
Design of World Structure	• A virtual house that experience heavy rains and cloudy to simulate the weather of when the natural disaster usually occurs.
Geometry and Appearance	• The house and the item in the RTG bag require detailed design to render them in the application
Reference from Real World Models	• Reference model can be gathered from real world models, ensuring that the virtual version is similar to real ones, such as fire and storms

Table 11 *Button design*

Button	Description
	• RTG bag prep button • Allow user to enter the 3D virtual environment for the module
	• Flood button • Allow user to enter the 3D virtual environment for the module
	• Fire button • Allow user to enter the 3D virtual environment for the module
	• Storm button • Allow user to enter the 3D virtual environment for the module
	• Home button • Direct user back to the main menu
	• Settings button • Allow user to navigate to settings interface
	• Restart button • Let user restarts the module if needed
	• Resume button • Let user resume the module from where they left of

3.5 Building and Implementation

The core functionalities of the Disaster Prep application were developed during this phase. The main modules include two primary components: the RTG bag preparation module and the disaster simulation module. C# scripting is used to enable users to interact with virtual objects, navigate realistic disaster environments, and perform critical safety tasks. An audio settings menu is also provided, allowing users to adjust background sounds and alerts. Finally, the module prototypes are integrated with C# scripts to link each disaster scenario, and the user's movement through the virtual environment.

Table 12 *Application Asset Development*

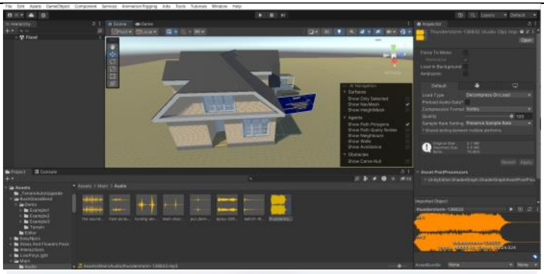
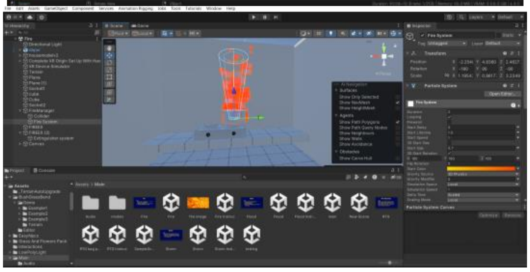
Assets	Development	Description
Audio		All of the audio was acquired from Pixabay website and would be stored in the Moving Picture Experts Group Layer-3 Audio (MP3) format.
Graphics		The storyboard and interface for the application were designed using Canva as the platform. The designs were then downloaded and implemented into the application.
3D model		Almost all of the 3D model for the application were created using Blender. All of the items available in the application were mostly downloaded and adjusted using Blender software such as the RTG bag and the items within.
Particle System		Some particle systems were implemented in the application to create a realistic environment such as the fire and the extinguisher.

Table 12 shows the development of the assets for the application for the purpose of making it more immersive for the users. These assets help in strengthening the immersive effect for the users and enhances the interactive quality of the application, making sure the application provide engaging and realistic VR experience.

Table 13 *Integration in Unity*

<table>
<tr><th>Function</th><th>C# Script</th><th>Description</th></tr>
<tr><td>SceneLoaderVR: Load scene using button interaction</td><td>

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;

public class SceneLoaderVR :
MonoBehaviour
{
    [SerializeField] private string
sceneToLoad;

    public void LoadScene()
    {
        if
(!string.IsNullOrEmpty(sceneToLoad))
        {

SceneManager.LoadScene(sceneToLoad);
        }
        else
        {
            Debug.LogWarning("Scene
name is empty!");
        }
    }
}
```

</td><td>This script is used to load a new scene when a button is pressed in a VR environment. The `sceneToLoad` string is assigned through the Inspector, and the `LoadScene()` method checks if it's valid before calling `SceneManager.LoadScene()`. This helps prevent empty scene names and makes scene navigation modular and dynamic.</td></tr>
<tr><td>XRSocketTagInteractor: Restrict interaction to specific tags</td><td>

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using
UnityEngine.XR.Interaction.Toolkit;

public class XRSocketTagInteractor :
XRSocketInteractor
{
    public string targetTag;

    public override bool
CanHover(IXRHoverInteractable
interactable)
    {
        return
base.CanHover(interactable) &&
interactable.transform.tag ==
targetTag;
    }

    public override bool
CanSelect(IXRSelectInteractable
interactable)
    {
        return
base.CanSelect(interactable) &&
interactable.transform.tag ==
targetTag;
    }
}
```

</td><td>This custom XR socket interactor overrides the base class to only allow interactions (hover or select) with objects that have a specific tag. `targetTag` is a string that filters which interactables are accepted, ensuring that only intended objects can snap to the socket.</td></tr>
</table>

Table 13 *Integration in Unity (Continued)*

<table>
<tr><td>SprayOnInput: Control particle effect for spray</td><td><pre>using UnityEngine;
using UnityEngine.XR.Interaction.Toolkit;

public class SprayOnInput : MonoBehaviour
{
    public ParticleSystem sprayEffect;
    private XRBaseController controller;

    public void StartSpray()
    {
        sprayEffect.Play();
    }

    public void StopSpray()
    {
        sprayEffect.Stop();
    }
}</pre></td><td>A simple VR input controller script that activates and deactivates a spray particle system (e.g., a fire extinguisher). The `StartSpray()` method begins the effect, while `StopSpray()` stops it. This script can be linked to XR events or button input logic.</td></tr>
<tr><td>FireDamageHandler: Handle fire extinguisher interaction</td><td><pre>using UnityEngine;

public class FireDamageHandler :
MonoBehaviour
{
    public ParticleSystem fireEffect;
    private float fireStrength = 1f;

    private void
OnParticleCollision(GameObject other)
    {
        if (other.CompareTag("Spray"))
        {
            fireStrength -= Time.deltaTime
* 0.5f;

            var emission =
fireEffect.emission;
            emission.rateOverTime = 100f *
fireStrength;

            if (fireStrength <= 0f)
            {
                fireEffect.Stop();
            }
        }
    }
}</pre></td><td>This script detects when a spray particle (tagged "Spray") collides with a fire effect. The `fireStrength` gradually decreases, reducing the emission rate over time. When the fire is fully extinguished, the particle system stops. This simulates putting out a fire in a realistic and interactive way.</td></tr>
</table>

Additionally, the C# scripts were created to ensures the primary function of the application runs smoothly. For instance, manage scene loader, particle system for extinguishing fires, and avoiding sockets from overlapping. Table 13 provides explanations of these functions.

3.6 Deploy and Maintenance

In the final phase, both functional testing and user acceptance testing will be conducted. If any issues are identified during this stage, the project will revert to the earlier phase to modify and correct the integrated functions accordingly.

Table 14 *System Functionality Testing*

Test	Expected Result	Actual Result	Action needed

RTG Bag Prep Button	Load the RTG Bag Prep Scene		
Flood Button	Load the Flood Scene		
Fire Button	Load the Fire Scene		
Storm Button	Load the Storm Scene		
Home Button	Navigate to Main Scene		
XR Grab Interaction	Object can be grabbed in the scene without any glitches	Works Well as expected	None
XR Release Interaction	Object can be released smoothly and fall naturally with gravity		
Audio	Audio be played without any issue		
Ensure the box collider prevents object from falling	User cannot move through object with box collider		
Player movement	Player can move smoothly in the virtual environment without any problem		
Instruction Panel	Instruction panel transition smoothly	Half of the module's instruction need improvement	Finalize instruction panel and make it work smoothly
Particle System for the fire and extinguisher	Player should be able to put out the fire using the fire extinguisher	Works well as expected	None

The functional testing results are shown in Table 14, with the corresponding corrective actions taken to ensure optimal performance and improve the user experience within the VR environment. User acceptance testing will be covered in Section 4.

4. Results and Discussion

User acceptance testing was conducted to ensure the application operates as expected. Each module's performance was assessed, and the application's overall usability was evaluated using the System Usability Scale (SUS) [14]. The SUS is a ten-item Likert scale designed to provide an overall assessment of perceived usability from the user's perspective. A total number of 20 respondents are involved in the user acceptance testing. The form was distributed after the app testing. Figure 6 and Figure 8 shows the questions that were asked in the form.

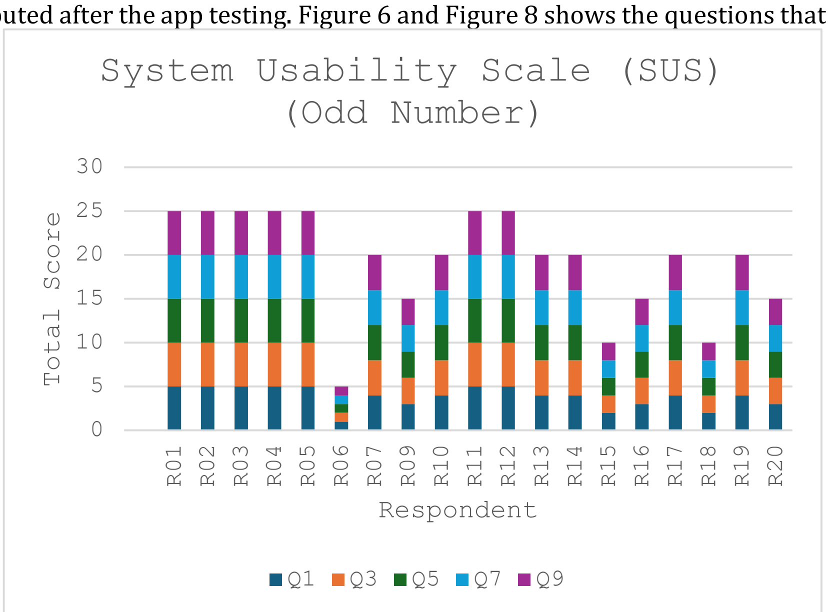


Fig. 5 *System Usability Scale Output (Odd Number)*

Question 1: I think that I would like to use this VR application frequently.
Question 3: I thought the application was easy to use.
Question 5: I found the various functions in this VR application were well integrated.
Question 7: I would imagine that most people would learn to use this VR application very quickly.
Question 9: I felt very confident using the VR application

Fig. 6 *System Usability Scale Questions (Odd Number)*

As shown in Figure 5, the majority of respondents chose 4 (Agree) and 5 (Strongly Agree) for the positive statements, indicating that they found the application to be satisfactory and user-friendly. Overall, the results reflect a high level of user satisfaction and effective application usability.

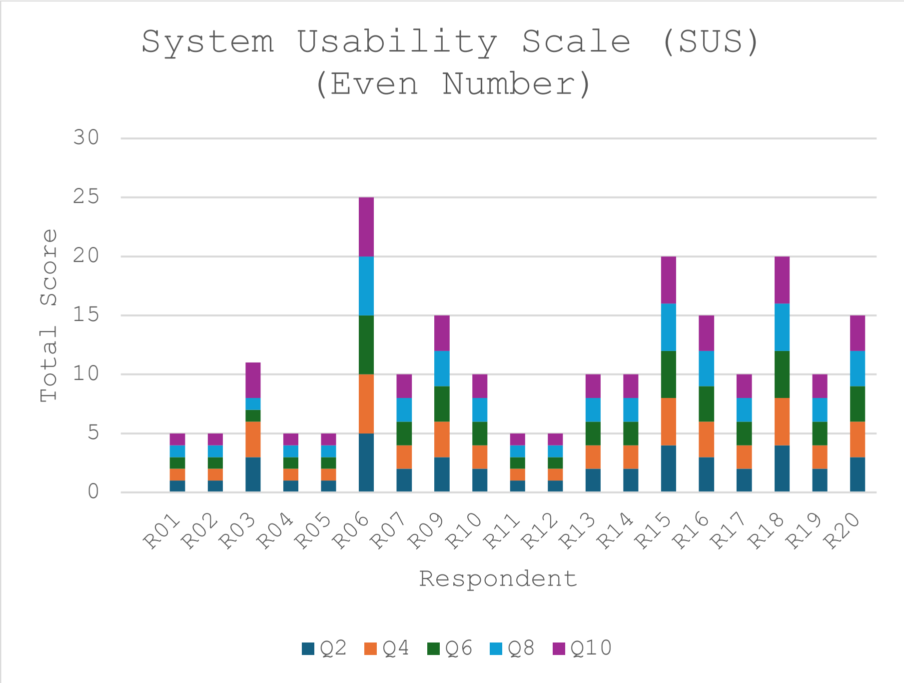


Fig. 7 *System Usability Scale Output (Even Number)*

Question 2: I found the application unnecessarily complex.
Question 4: I think that I would need assistance to use the VR application.
Question 6: I thought there was too much inconsistency in this application.
Question 8: I found the application very cumbersome to play.
Question 10: I needed to learn a lot of things before I could get going with this application.

Fig. 8 *System Usability Scale Questions (Even Number)*

Figure 7 illustrates that responses to the negative statements mostly fall between 1 (Strongly Disagree) and 3 (Neutral), suggesting that users did not encounter major issues with the application. These low ratings for negative items align with the high ratings for positive statements, reinforcing the perception that the system is user-friendly and satisfactory.

Table 15 *Respondent's Score*

Respondent	Item Score										Total Score
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	
R01	5	1	5	1	5	1	5	1	5	1	100
R02	5	1	5	1	5	1	5	1	5	1	100
R03	5	3	5	3	5	1	5	1	5	3	85
R04	5	1	5	1	5	1	5	1	5	1	100

R05	5	1	5	1	5	1	5	1	5	1	100
R06	1	5	1	5	1	5	1	5	1	5	0
R07	4	2	4	2	4	2	4	2	4	2	75
R08	5	1	5	1	5	1	5	1	5	1	100
R09	3	3	3	3	3	3	3	3	3	3	50
R10	4	2	4	2	4	2	4	2	4	2	75
R11	5	1	5	1	5	1	5	1	5	1	100
R12	5	1	5	1	5	1	5	1	5	1	100
R13	4	2	4	2	4	2	4	2	4	2	75
R14	4	2	4	2	4	2	4	2	4	2	75
R15	2	4	2	4	2	4	2	4	2	4	25
R16	3	3	3	3	3	3	3	3	3	3	50
R17	4	2	4	2	4	2	4	2	4	2	75
R18	2	4	2	4	2	4	2	4	2	4	25
R19	4	2	4	2	4	2	4	2	4	2	75
R20	3	3	3	3	3	3	3	3	3	3	50
Average Score											71.75

Table 5.3 above presents the analysis of respondents' scores from the Google Form questionnaire. The average score is calculated using the formula below.

$$SUS\ score = 2.5 \times \left(\sum_{k=1,3,5,7,9} (Response_k - 1) + \sum_{j=2,4,6,8,10} (5 - Response_j) \right)$$

$$\text{Odd items} = \textstyle\sum_{k=1,3,5,7,9}(Response_k - 1)$$

$$\text{Even items} = \textstyle\sum_{j=2,4,6,8,10}(5 - Response_j)$$

Therefore,

$$\text{Average score} = \frac{\text{Total score of R1 + R2 + R3 +}\cdots\text{R35}}{20}$$

$$= 71.75$$

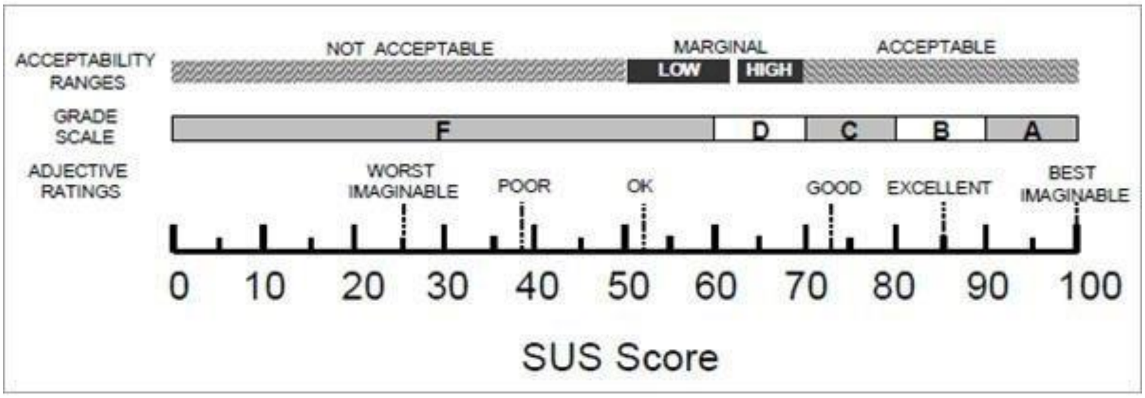


Fig. 9 *System Usability Scale (SUS) Score [14]*

The total scores for each question in the user testing were calculated using the System Usability Scale (SUS) method. With an average score of 71.75, the results fall within the "acceptable" range according to the Acceptability Ranges scale shown in Figure 9. This score corresponds to a grade of "C" and an adjective rating of "Good." Overall, the developed application successfully meets the needs of its intended users.

5. Conclusion

In conclusion, the Disaster Prep application successfully meets its objectives of enhancing disaster preparedness through immersive and interactive virtual reality experiences. By simulating realistic scenarios, such as preparing

Applied Information Technology and Computer Science Vol. 7 No. 1 (2026) p. 117-134

an emergency "Ready To Go" (RTG) bag, putting out fires, and sheltering from storms. The application enables users to practice and internalize critical survival actions in a safe environment.

The development process involved the design of a 3D environment using Unity, implementation of VR features, and evaluation through both functional and user acceptance testing. The results show positive feedback from users, highlighting the application's intuitiveness, usefulness, and realism. These outcomes indicate the application is effective for its target users, particularly the public aged 12 and above. The strengths and weaknesses of the Disaster Prep application are summarized in the Table 16 below.

Table 16 *Advantages and Disadvantages of Disaster Prep Application*

Advantages	Limitations
Provides a realistic and immersive environment to simulate floods, fires, and storms	Requires VR hardware (e.g., Oculus Rift), which may not be affordable or accessible to all users
Encourages better disaster response through interactive, hands-on learning	May cause motion sickness or discomfort for some users, especially first-timers or elderly individuals
Covers multiple disaster types in a single application, unlike most existing solutions	Limited to single-user experience; does not support collaborative or multiplayer drills
Improves retention and user engagement compared to traditional methods (e.g., books, videos)	Limited customization features for users or scenario variability in the current version
Safe training environment for high-risk disaster situations without real-world danger	Requires sufficient space and safety awareness when used in VR due to physical movement

Looking ahead, future development may include expanding the application to incorporate more disaster types, multiplayer training sessions, enhanced customization, and accessibility improvements. With continued refinement, Disaster Prep has strong potential as a powerful educational tool for schools, emergency response teams, and public institutions to raise awareness and build a culture of disaster readiness in Malaysia and beyond.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

*The authors confirm contribution to the paper as follows: **study conception and design:** Hadzilhareeq Hairizan, Dr. Norhanifah Murli; **data collection** Hadzilhareeq Hairizan, Dr. Norhanifah Murli; **analysis and interpretation of results** Hadzilhareeq Hairizan, Dr. Norhanifah Murli; **draft manuscript preparation:** Hadzilhareeq Hairizan, Dr. Norhanifah Murli. All authors reviewed the results and approved the final version of the manuscript.*

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