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DISASTERPREP: GAMIFIED MOBILE EDUTAINMENT FOR FUTURE DISASTER PREPAREDNESS AND RESILIENCE

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Abstract

In 2021, Malaysia experienced a significant flood, known as 'the worst flood of the century'. In 2019, a severe haze led to the closure of over 2000 schools. Over half of the surveyed individuals rated their disaster preparedness knowledge as poor or fair. While the government has taken steps to manage disasters, there is still a lack of preparedness at the community level. This research aims to assess the target users' current disaster preparedness knowledge and behaviours. To address this, we develop a user-centred mobile application that combines education and entertainment elements to enhance disaster preparedness and resilience. DisasterPrep introduces a three-dimensional (3D) virtual environment using a metaverse concept, incorporating gamification and user engagement to simulate calamities in Malaysia. The expected outcome of this research is to promote an innovative mobile edutainment application that enhances disaster preparedness and response education. It features interactive modules, gamified challenges, and real-time alerts, supported by a user-friendly interface with quizzes, simulations, and localized risk assessments. Users can explore four main menus—training, flood, earthquake, and disaster outbreak—offering realistic preparation, response, and recovery scenarios. The app includes voiceover options in English and Malay, with e-certificates awarded upon level completion. Usability testing showed improved knowledge, positive behavioural changes, and community resilience. All seven test cases were successfully passed. By leveraging immersive simulations and interactive experiences, DisasterPrep cultivates critical skills, increases engagement, and improves accessibility.

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Additionally, it supports sustainability through reduced paper use, cost savings, and energy efficiency, ensuring broad accessibility while promoting disaster resilience.

Keywords: Disaster; edutainment; gamification; preparedness; resilience

Abstrak

Pada tahun 2021, Malaysia mengalami banjir besar, yang dikenali sebagai 'banjir terburuk abad ini'. Pada 2019, jerebu teruk menyebabkan lebih 2000 buah sekolah ditutup. Lebih separuh daripada individu yang terlibat melakukan penilaian kendiri terhadap pengetahuan kesediaan bencana pada tahap rendah dan sederhana. Walaupun kerajaan telah mengambil langkah untuk menguruskan bencana, masih terdapat kekurangan persediaan dalam kalangan masyarakat. Penyelidikan ini bertujuan untuk menilai pengetahuan dan tingkah laku masyarakat semasa kesiapsiagaan bencana. Untuk menangani perkara ini, satu pembangunan aplikasi mudah alih berpusatkan pengguna yang menggabungkan elemen pendidikan dan hiburan untuk meningkatkan kesiapsiagaan dan daya tahan bencana. *DisasterPrep* memperkenalkan persekitaran maya tiga dimensi (3D) menggunakan konsep metaverse, menggabungkan gamifikasi dan penglibatan pengguna untuk mensimulasikan malapetaka di Malaysia. *DisasterPrep* ialah aplikasi *edutainment* mudah alih yang meningkatkan kesiapsiagaan bencana dan pendidikan tindak balas. Ia menampilkan modul interaktif, cabaran gamifikasi, dan makluman masa nyata, disokong oleh antara muka mesra pengguna dengan kuiz, simulasi dan penilaian risiko setempat. Pengguna boleh meneroka empat menu utama—latihan, banjir, gempa bumi dan wabak bencana—yang menawarkan senario penyediaan, tindak balas dan pemulihan yang realistik. Aplikasi ini menawarkan pilihan alih suara dalam bahasa Inggeris dan Melayu, dengan e-sijil diberikan setelah tamat keseluruhan tahap. Ujian kebolehgunaan menunjukkan peningkatan pengetahuan, perubahan tingkah laku yang positif dan daya tahan komuniti. Kesemua tujuh kes ujian telah berjaya lulus. Dengan memanfaatkan simulasi yang mengasyikkan dan pengalaman interaktif, *DisasterPrep* memupuk kemahiran kritikal, meningkatkan penglibatan dan meningkatkan kebolehcapaian. Selain itu, ia menyokong kemampanan melalui pengurangan penggunaan kertas, penjimatan kos dan kecekapan tenaga, memastikan kebolehcapaian yang luas sambil menggalakkan daya tahan bencana dalam kalangan masyarakat.

Kata kunci: Bencana; didik hibur; gamifikasi; kesediaan; ketahanan

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1.0 INTRODUCTION

Malaysia has encountered multiple disasters, with floods being the most prevalent. In March 2023, heavy rainfall led to flooding in six states, affecting over 40,000 people and resulting in six reported deaths (Utusan Malaysia, 2023). The flood losses were valued at RM 6.1 billion in 2021 and RM 622.4 million in 2022 (Department of Statistics Malaysia, 2023). The significant loss in 2021 was due to the worst flood Malaysia had experienced since 2014. In addition to floods, the country experiences annual haze, with the most recent major haze disaster occurring in 2019, caused by forest fires and transboundary haze (New Straits Times, 2019; Utusan Borneo, 2019). Consequently, 2,459 schools in eight states were closed as the Air Pollutant Index (API) exceeded 200 (The Star, 2019). Given these statistics, it is crucial to prepare for such disasters to ensure better responses when they occur.

The urgency of disaster preparedness and resilience through mobile edutainment has been identified in three recent problem statements. First, there is a general lack of awareness and comprehension of catastrophe risk and preparedness in many areas. During disasters, this knowledge gap may make people more vulnerable. Residents of the Klang Valley were caught off guard by the sudden and catastrophic nature of the 2021 flash flood, which no one had anticipated. High tides and over double the annual rainfall, which was the source of the flood, were the contributing factors, according to (Harian Metro, 2021). However, this does not adequately account for the enormous loss that the flood victims endured. Berita Harian discovered that many people ignored METMalaysia's flood prediction because of the rain since early November, as reported by (Wan Izatul, 2021). Therefore, they were uninformed of the disaster and unprepared for it. A review of 222 publications on behavioural training and individual readiness in environmental disasters was conducted (Fazeli et al., 2024). They discovered that the majority of communities globally lack sufficient knowledge about preparedness. Second, information about disaster preparedness is impractical. These days, radio, television, and social media campaigns are used to inform people about disaster preparedness (Sobian, 2016). Nevertheless, there is no assurance that people who see infographics online and on social media platforms will understand and act upon the information. Malaysia's communities do not adequately prepare their communities for disasters (Sobian, 2016). Only cities vulnerable to disasters are more prepared because they have started taking precautions and grown accustomed to the circumstances. That is not how things work in other communities.

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1.1 Gamification and Edutainment-Related Application

This subsection reviews existing edutainment applications and games-related disaster preparedness. Each edutainment program has unique features, security measures, and limitations. Nevertheless, they all share the same goal: to educate players about disaster preparedness. Table 1 compares the various disaster edutainment features with our proposed mobile application known as DisasterPrep. "Stop Disasters!" is a web-based strategy simulation game developed by the United Nations Office for Disaster Risk Reduction. Players face five natural hazards—wildfires, earthquakes, floods, tsunamis, and hurricanes—emphasizing the importance of city planning in disaster risk management (United Nations Office of Disaster Risk Reduction, 2019). Users can select a disaster and adjust the difficulty without logging in, ensuring easy access. The Disaster Game, developed by the American Red Cross, is an interactive in-person card RPG focused on disaster preparedness and assembling 72-hour kits. Each session lasts 20 to 40 minutes, during which players receive resources and need cards to match and collaborate (American Red Cross, 2023). Dice and Disasters, designed by the Washington Emergency Management Division, is a tabletop RPG similar to Dungeons and Dragons. Instead of a Dungeon Master (DM), there is a Master of Disaster (MoD), guiding players through campaigns that simulate disaster preparation, response, and recovery missions (Washington Emergency Management Division, 2022).

Disaster Master is an educational web simulation game created by the United States Department of Homeland Security, specifically designed for students. In this game, players engage in narrative-driven scenarios where they assist characters by answering questions related to safety precautions for various disasters (US Department of Homeland Security, 2023). Players earn points for correct answers, while incorrect responses may lead to the termination of the game. The game features eight progressively challenging levels, and players who complete all levels can print a graphic novel based on their gameplay experience. On the other hand, Disasters is a computer strategy simulation game developed by Crazy Duck that is currently available for early access (Crazy Duck, 2022). Players collect research points in this game to unlock regulations to prevent potential disasters. Throughout the gameplay, players must also manage smaller disasters that can occur, balancing their responses to minimize negative impacts on the environment, public satisfaction, and the severity of disasters.

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Table 1. A comparison with existing related disaster preparedness application

Features	DisasterPrep	Stop Disasters!	The Disaster Game	Dice & Disasters	Disaster Master	Disasters
Mobile apps	/	X (Web browser)	X (Card-based)	X (tabletop roleplaying game)	X (Web browser)	X (city planning & legislations)
Disease outbreak	/	X	X	X	X	X
3D environment	/	X	X	X	X	X
Voice-over (English & Malay)	/	X	X	X	X	X
Quiz-based	/	X	X	X	X	X
Notes	/	X	X	X	X	X

The low interest in and participation in disaster preparedness education constitutes the third issue. Another problem is that many people believe they do not need to learn how to prepare for disasters or do not want to. This research indicates that most people believe Malaysia is safe from disasters and will not be impacted even if one occurs (Sobian, 2016). On the other hand, more disasters are happening there. Furthermore, the existing approaches to disaster preparedness teaching leave students bored and uninterested. As a result, many lost interests in learning more about disaster preparedness. This led to a carefree, uninformed populace and ill-prepared municipalities to deal with disasters. To enhance disaster preparedness and resilience, this study seeks to ascertain the target users' present knowledge and behaviours related to disaster preparedness. Furthermore, it designs a user-centred mobile application that blends educational and entertaining components.

This paper aims to investigate target users' current disaster preparedness knowledge and behaviours and design a user-centred mobile application that combines education and entertainment elements to enhance disaster preparedness and resilience. Thus, DisasterPrep mobile edutainment is proposed as a virtual futuristic teaching with metaverse technologies involving virtual gamification and user engagement that simulate calamities in Malaysia. It aims to educate society, especially young adults, on disaster preparedness. This mobile application will have gamification elements to engage and interest the target users in the learning process.

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1.2 Research Objectives

DisasterPrep aims to fulfil three main objectives, which are (i) to investigate current disaster preparedness knowledge and behaviours among target users, (ii) to design a user-centred mobile application that combines education and entertainment elements as the new learning path to enhance disaster preparedness and resilience of citizens and (iii) to meet social needs by educating the community early to increase awareness of disaster preparedness.

2.0 MATERIALS AND METHODS

This research used quantitative research, which analyses and collects data in advance to identify patterns in understanding disaster preparedness for mobile applications. As illustrated in Figure 1, this study used the Agile methodology in four stages. Agile is renowned for its incremental and iterative methods, which are flexible and adaptable to change, making it a good fit for mobile development. Following the completion of the preliminary design, a user-centred approach will guide the design and development process. The purpose of the testing phase is to evaluate the suggested application's functionality. Due to Agile's flexibility, these phases can overlap and are iterative (Omonije, 2024).

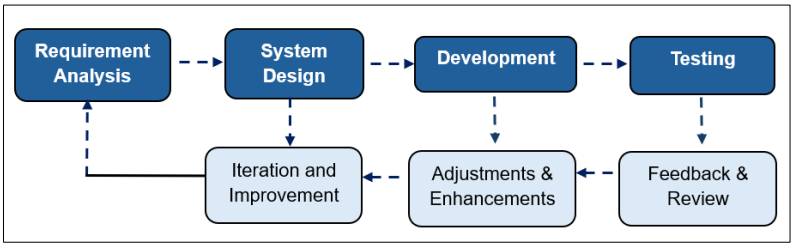

Figure 1. Agile’s phases for DisasterPrep mobile application

2.1 Requirement Analysis

This requirement analysis aims to identify gaps and areas for improvement by examining target users' current disaster preparedness knowledge and behaviours. The preliminary survey employs purposive sampling to target participants with relevant knowledge or experience in disaster preparedness, ensuring valuable insights for the design process. This method helps gather feedback on user needs, preferences, and potential challenges. Surveying before mobile development allows the identification of critical features, content priorities, and usability requirements, ensuring the application is user-centred and effectively addresses the intended objectives. In 2023, an online preliminary survey via MS Form was conducted to determine the degree of preparedness knowledge as a guide before design and development. The respondents' demographics are the main focus of the first three questions.

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The age distribution of respondents is presented in Table 2, which includes a diverse group of university students and members of the public. In this initial survey, users 41 years old and older cast the most votes. Urban areas rank highest among the participants' residing locations, followed by suburban and rural areas (Table 3).

Table 2. Age demographic and distribution of the respondents' living areas

Age	Percentage (%)	Living area	Percentage (%)
18 - 25	25	Urban	56
26 - 40	29	Suburban	39
41 and above	46	Rural	6

The respondents were mainly adults aged 41 and above (46%) and were employed (63%), as shown in Table 3. This preliminary survey focuses on the status of employed people because properties such as houses and cars or motorbikes are exposed to disasters.

Table 3. The distribution of respondent's employment status

Employment status	Percentage (%)
College/University student	24
Employed	63
Retired	11
School student	1
Unemployed	1

The following survey shows the findings in Table 4 for the types of disasters faced by the respondents. The top three chosen were flood/tsunami, haze, and disease outbreak (excluding COVID-19), with 32%, 26%, and 15%. Even though the earthquake is not the most voted on, most participants come from a country that does not face it. However, the impact could be more potent than that of haze. Therefore, the three disasters chosen for the subsequent development game simulation are floods, disease outbreaks and earthquakes to enhance disaster preparedness and resilience.

Table 5 discovers the user expectations for mobile edutainment from various ages, with 34% and 32% of the respondents' expecting simulations and educational notes, respectively. 20% of the respondents also expect an emergency contacts or directory. However, the emergency contact is less practical to be included in the game application. Therefore, gamification elements, educational notes and disaster simulation are proposed.

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Table 4. The number of responders who have experienced various disaster

Type of disaster	Percentage (%)
Building collapse	0
Drought and/or Extreme heat	13
Disease outbreak	15
Earthquake	2
Explosion and/or Fire	3
Flood and/or tsunami	32
Haze	26
Landslide	0
Major transportation accidents	4
None	6

Table 5. Respondents' expectations from a mobile game for disaster preparedness

User expectation	Percentage (%)
Directory/Emergency contacts	20
Educational notes	32
Gamification elements	12
Other	1
Simulations	34

Table 6 summarises that most users would like to learn more about the top three things: preparing emergency kits, communication, and evacuation plans. Thus, a game simulation trains the user to pick up the necessary items during a disaster, and training mode is considered via practical virtual digital training. Medical assistance, communication and evacuation plans are not chosen as this proposed application focuses on preparedness via game-based learning. Based on Table 7, simulation receives the highest vote by the user on the game type for a mobile application. This was followed by word games, role-playing games and match 3.

Table 6. Respondents' expectations from a mobile game for disaster preparedness

User interest	Percentage (%)
Communication plans	23
Evacuation plans	22
Hazard mitigation	13
Medical assistance	18
Preparing emergency kits	24
Other	0

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Table 7. Respondents' type of game chosen for the mobile application

Type of game	Percentage (%)
Card games (e.g: Uno)	6
Hidden object (e.g: Magical Mystery)	11
Match 3 (e.g: Candy Crush)	13
Other	1
Role-playing game (RPG)	13
Running games (e.g: Subway Surfers)	7
Simulation	23
Tic Tac Toe/Connect 4	4
The Game of Life/Monopoly	9
Word games (e.g.: Word search)	14

2.2 System Design

During this stage, the system architecture is outlined, the requirements are refined, and the intended user interface (UI) and prototypes are designed. Early visual representations and prototypes of the user-centred mobile application with entertainment and educational components are made to validate design concepts. The use case diagram for the suggested application is shown in Figure 2. The user can choose any of the four main menus, and each of them will have sub-functions. In this system design, all flow and questions for each disaster have been scrutinised to tailor the time given during game simulation. Before the final caption is added to the application, the translation for the Malay setting is reviewed.

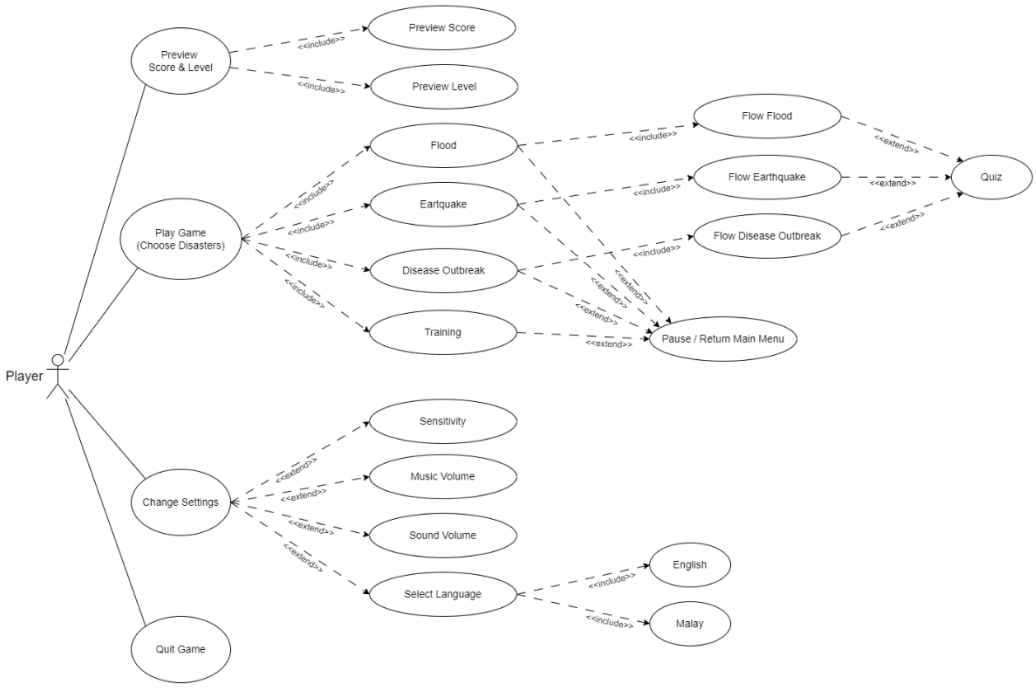

Figure 2. Use case diagram of the proposed disaster simulation game application

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2.3 Development

This design phase aims to develop functional features in a short cycle to ensure high-quality code through frequent testing and continuous integration. Each application interface verified during system design is developed in the Unity platform. The menu is divided into four menus on the interface page: (i) Play Game (Choose scenario), (ii) Change settings, (iii) Preview Score and Level, and (iv) Quit Game. Code is integrated frequently, and manual tests are run to detect issues early during development. Agile methodology embraces change, allowing the development phase to quickly adapt to new requirements or changes (Omonije, 2024).

2.4 Testing

Early flaw detection and correction during the unit integration process is the goal of the testing phase. Test cases and plans are created, the test scenario environment is simulated, and the cases are assessed for manual and functional testing. Exploratory and usability testing are done manually to find problems that automated tests could overlook. End users test the application during functional testing to make sure it satisfies functionality criteria and is the most user-friendly mobile educational tool for promoting disaster preparedness. Therefore, if necessary, the application can be improved. Agile methodology benefits mobile development projects because of its focus on teamwork, iterative progress, and ongoing feedback (Marnewick & Marnewick, 2022).

Table 8 displays a sample of test cases that have been carried out. In this phase, seven test cases are developed (main menu, game scope, setting, flood, earthquake, disaster outbreak, training gameplay page). The function will be inspected and redesigned for improvement if any status failure is found.

Table 8. Test cases of the game scope page for DisasterPrep application

No.	Description of Test Data	Expected Result	Actual Result	Status
1.	Only allow the player to play a game once after finishing training.	The warning popup warns the player to go through training first whenever the first-timer player chooses another scope.	The warning popup warns the player to go through training first whenever the first-timer player chooses another scope.	Pass
2.	Start simulation of the flood when the flood	The flood simulation 3D environment appeared for the	The flood simulation 3D environment	Pass

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	button is clicked.	player to start playing.	appeared for the player to start playing.	
3.	Start simulation of the earthquake when the earthquake button is clicked.	The earthquake simulation 3D environment appeared for the player to start playing.	The earthquake simulation 3D environment appeared for the player to start playing.	Pass
4.	Start simulation of disease outbreak when the disease outbreak button is clicked.	The disease outbreak simulation 3D environment appeared for the player to start playing.	The disease outbreak simulation 3D environment appeared for the player to start playing.	Pass

3.0 RESULTS AND DISCUSSION

DisasterPrep offers informal interactive learning for disaster preparedness via game simulation with four primary menus: (i) training, (ii) flood, (iii) earthquake, and (iv) disaster outbreak. It also provides three levels (beginner, intermediate, hard) of quiz-based games on disaster preparedness knowledge in a 3D environment via game simulation concepts. Voiceover during simulation games is also provided in English and Malay, depending on the language setting.

Gamification includes scenarios with different difficulties, zones, and levels where users must prepare, respond, or recover from the disaster. Users can also download the e-certificate of completion for each level of the disaster chosen. The following Figures 3-6 describe the interfaces in the DisasterPrep application for the English setting.

3.1 Simulation - Flood

In the flood game simulation, players begin by turning on a virtual television to receive real-time updates on the flood situation in their area, as shown in Figure 3. The next phase is for them to locate and collect necessary items from within their home to prepare for flooding. After they are equipped, players venture outside their virtual home to personally evaluate the water situation. Players must accomplish these tasks as soon as possible and locate a haven before the waves rise and threaten to swallow them. A popup window with more information will also appear if the player touches or picks up the object. It will ask the player to prepare for flooding before the disaster in that game occurs.

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Figure 3. Interface of flood page game simulation in DisasterPrep

3.2 Simulation - Disaster Outbreak

The game flow simulation for disease outbreaks is explained in this section. Players start the game by grabbing a mobile phone to check the status of the disease outbreak. Players are told to visit the mall and purchase everything they need to survive. Reminder popups to maintain space will be displayed.

Once the player has gathered all the groceries, they must go to the counter and pay for those products, as shown in Figure 4. The players have to answer a call on their cell phones when they get home. After disinfecting every floor in the house with a mop, participants answer a quiz to confirm their understanding and level of readiness, so concluding the simulation.

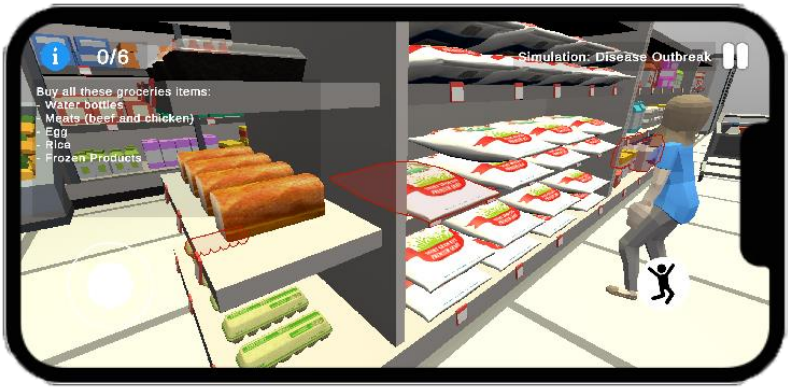

Figure 4. Interface of disaster outbreak page game simulation in DisasterPrep

3.3 Simulation - Earthquake

Players start the earthquake game simulation by turning on a cell phone or virtual television to get the most recent information on the local earthquake scenario. A list of necessary goods to bring and guidance on where to find a safe spot to shelter from earthquakes will be provided through pop-up information. Figure 5 uses the suggested DisasterPrep application to show the safe place to stay during the earthquake.

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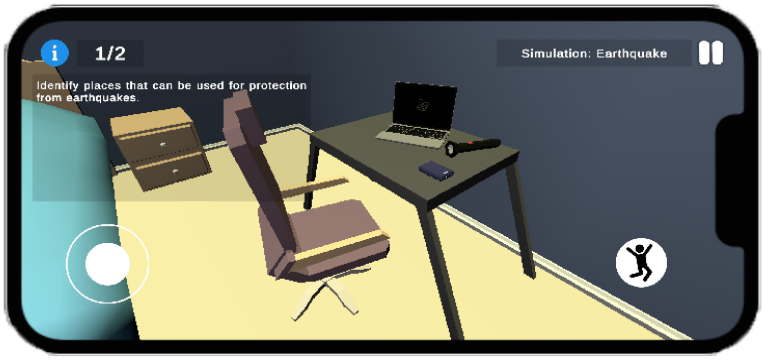

Figure 5. Interface of earthquake page game simulation in DisasterPrep

The score interface page is displayed in Figure 6 once the player answers the quiz about the chosen disaster. The player can get a digital certificate of achievement after finishing every level. Considering DisasterPrep has features such as interactive learning, real-time information, resource accessibility, community participation, hands-on training, and assessment, it can significantly improve the teaching and learning of geography, environmental science, and public health.

For example, professionals and students could collaborate in common areas for remote learning and work. In the metaverse concept, bringing disparate experiences together under one roof could lead to more engaged user experiences. Teachers could lead field trips without going to the location in person. Additionally, through this 3D virtual environment, the metaverse events can offer more experiential digital learning opportunities.

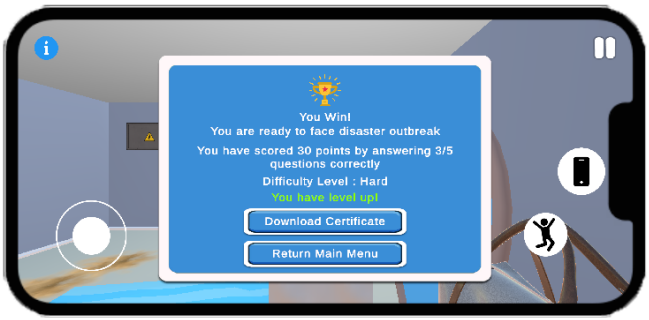

Figure 6. Interface sample of score achievement for disaster outbreak quiz

DisasterPrep can significantly enhance the teaching and learning of geography, environmental science, and public health by providing the following values: interactive learning, real-time information, resource accessibility, community engagement, practical training, and assessment. Professionals and students, for instance, could join common areas for studying

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and working remotely. There is potential for more engaged user experiences in the metaverse concept when the dispersed experiences are combined under one setting. Instructors could conduct field trips without physically visiting the destination. Furthermore, the metaverse events may present more significant opportunities for experiential digital learning via this 3D virtual environment. By incorporating these features, a mobile disaster recovery application can enhance teaching and learning, making them more dynamic, effective, and responsive to real-world needs.

a) **Interactive Learning:** The application provides interactive simulations and scenarios to teach users about disaster preparedness, response, and recovery, making learning more engaging and practical.
b) **Resource Accessibility:** The application can be a repository of educational resources, guidelines, and best practices, accessible anytime and anywhere, ensuring continuous learning.
c) **Community Engagement:** It facilitates user communication and collaboration, enabling knowledge sharing and collective problem-solving during and after disasters.
d) **Digital Practical Training**: The application can offer step-by-step guides and checklists for disaster response, providing hands-on training and reinforcing theoretical knowledge with practical application via game simulation.
e) **Assessment and Feedback:** It includes quizzes (three difficulty levels) and assessments to test users' knowledge and provide feedback by displaying pop-up notifications, helping learners identify improvement areas and track their progress. The user can also earn an e-certificate of completion once each level is accomplished.

The findings from the disaster preparedness mobile edutainment project highlight the significance of user-centred design. They emphasize the necessity for interactive, immersive, and culturally adaptable features to enhance engagement and learning outcomes. Future development should focus on incorporating real-time data, localized risk assessments, and multilingual support to address the diverse needs of users. Moreover, sustainability should be prioritized in design choices such as energy-efficient architecture and reduced resource consumption. It can improve accessibility while aligning with global environmental objectives.

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4.0 CONCLUSION AND FUTURE WORKS

Three primary domains can be used to classify the possible effects of this application: society, education, and the country. In the education domain, it can improve curricula, serve as a digital learning tool for practice, offer teacher materials and resources, and support community projects. DisasterPrep has the potential to improve society by increasing public awareness of the value of disaster preparedness, fostering a culture of readiness, building community resilience through the provision of tools and resources, and guaranteeing that vulnerable groups, such as the elderly and disabled, have access to vital information and resources that are catered to their needs. Impacts on the nation include improved public health through edutainment on preventing and addressing disaster health risks, decreased economic impact from damage and recovery costs through improved preparedness and early response, and increased national preparedness.

Several disaster preparedness mobile applications have effectively enhanced readiness and response in different regions. The FEMA Mobile App in the United States provides real-time alerts and survival tips, improving community awareness during hurricanes and wildfires (Federal Emergency Management Agency, 2024). MyShake (2019), developed in California, detects earthquakes using smartphone sensors and sends early warnings, which proved valuable during the 2019 Ridgecrest earthquakes. In Japan, Yurekuru Call (2013) offers localized earthquake alerts and preparedness tips, leveraging advanced seismic monitoring to save lives. Disaster Alert (2017) by the Pacific Disaster Center provides global hazard updates and resources for timely decision-making during crises. However, none of these apps offer 3D virtual learning in an interactive gaming format with dual-language voice-over and quiz-based content to educate the community, such as DisasterPrep, and offer awareness of disease outbreak preparedness. Most existing applications focus on earthquake alerts and warnings.

In conclusion, DisasterPrep is an example of metaverse technology in action. This technology improves education about disaster preparedness and resilience by utilising immersive simulations, tailored and interactive learning experiences, real-time interaction, increased engagement, accessibility, and the development of valuable skills. Students learn in a setting that is more interesting, productive, and meaningful as a result. DisasterPrep recommends that mobile edutainment can have a lasting impact on individuals' preparedness and resilience mindset. It is also aligned with the National Disaster Management Agency (NADMA), which drives the establishment of strategic planning for disaster management and

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highlights that community-based education and awareness of disaster risk management could also lead to reducing the impact of disaster (Zainal Azman, 2017). It can aid in cultivating a long-term behavioural impact in a society where users who continue to use the mobile application over an extended period will showcase sustained disaster preparedness behaviours.

Future disaster preparedness mobile application improvements could include advanced AI for personalized learning paths and predictive analytics to tailor content to user behaviour and risks. Expanding multilingual support and cultural context would enhance global accessibility. Additionally, integrating augmented reality (AR) simulations and partnering with emergency response agencies for live updates could boost practicality and impact.

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