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Fire Drill Simulation Game for Primary School Students

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Abstract

A natural disaster represents a distressing incident that profoundly affects communities, resulting in significant casualties that disrupt their daily routines. Fire, as a facet of such calamities, ensues when flammable substances and gases intermingle, leading to the emission of heat and light. Research conducted in Malaysia reveals an alarming occurrence of over five thousand fire-related incidents within buildings. In response, the country has advised the primary schools to conduct fire drill simulations once or twice a year. However, the infrequent nature of these drills potentially hampers the retention of vital knowledge by the young students. Preliminary investigations have pinpointed the main challenge to conduct the drill simulations more frequently is the school's struggle to coordinate with the fire departments. Consequently, this study aims to devise a computer-based fire drill simulation game specifically for primary school pupils. Employing the Game Development Life Cycle (GDLC) approach offers the advantage of adaptability during the game's creation. The project will also incorporate the System Usability Scale (SUS) as a model to ensure the game's practicality and playability. Through this initiative, the intention is to enhance fire safety awareness among the students in an engaging and effective manner.

Keywords: Fire Drill, Simulation Game, Primary School, Students, Malaysia

Introduction

A devastating occurrence like natural disasters such as floods, tornadoes, and other geological events profoundly impacts communities, resulting in casualties, disruptions, damages, and rendering affected areas incapable of functioning without external assistance (Petrucci, 2012). Among these natural disasters is fire, characterized by a swift chemical reaction between combustible materials and gases, generating both heat and light. If the combination of fuel, oxygen, and heat is prevented or extinguished, a fire will not ignite (Mohamad Ismail, 2018). Findings and data from Malaysia's Fire and Rescue Department (FRDM) indicate that in 2023 alone from January to April, there are 6,326 open burning cases happened in Malaysia (Ahmad, 2023). Tragically in 2017, Malaysia was deeply shaken by distressing information when a school was engulfed in flames, leading to the tragic loss of 21 students, 2 teachers, and 1 warden. The cause of this devastating fire was reportedly attributed to a short circuit.

Additionally, the unfortunate demise of these innocent individuals resulted from structural flaws in the building and insufficient implementation of fire drill simulations (Mohamad Ismail, 2018).

A fire drill is an organized exercise carried out to ensure swift evacuation in the event of a fire, smoke, or other perilous circumstances within a building. This practice also informs occupants with the sound of a fire alarm. Two types of drills are commonly conducted: lockdown drills, where students remain in classrooms during emergencies, and evacuation drills, like fire drills where students vacate the building and assemble at designated areas. The aim of fire drills is to educate individuals about proper building evacuation methods, knowledge not typically covered in classrooms but obtained through guidance from firefighters and rescuers (Ismail, 2018). All schools are advised to perform fire drills at least once, with the National Union of Teachers (NUT) suggesting initiation at the beginning of each school year for new staff and students (Liz Burton, 2018). This practice is also endorsed in Malaysia, during a fire drill simulation.

Knowledge about fire is important because it can help the student to improve their level of awareness through a basic understanding of what the cause of the fire and what to do if the fire happens in schools. However, fire drill simulations are usually limited to one or two sessions per year in schools. Consequently, primary school students face difficulties during actual emergencies due to inadequate practice in fire drill simulations. A study manages by Yasmin (2018) shows that FRDM public education and awareness programs such as fire drills have been conducted for both rural or urban schools however due to some constraints, they only come to the school and other institutions to demonstrate a fire drill once or twice in a year. Moreover, irregular briefing can make the student easily forget about what they are learning.

To address this, digital learning exposure is proposed, enhancing their understanding and experience. To overcome this challenge, a solution is suggested: providing an accessible and easy-to-learn platform for basic fire drill simulations (Yasmin, 2018). Implementing simulation games emerges as an effective technique to engage primary school students in practicing fire drill procedures (Silva et al., 2013). These games immerse players in decision-making scenarios within a simulated environment, enabling them to grasp the implications of their choices (Sitzmann, 2011). Evidence from studies suggests that simulation games heighten student motivation and foster a more profound connection with instructional material, providing an encouraging platform for both students and educators to conduct fire drill practices more effortlessly. Furthermore, consistent engagement with simulation games can enhance students' retention of subject matter (Havola et al., 2020). It is also essential to note that prior testing of each game is crucial to ensure its usability and playability for users (Moreno-Ger et al., 2012).

Fire Drill in Malaysia and Its Problem

A fire drill is essential for everyone's safety and is especially crucial for children, who are particularly vulnerable due to their limited understanding of fire safety. During school fire drill simulations, specific steps are followed by both teachers and students. Teachers must be alert to the distinctive bell ring signal, signifying the commencement of the drill. They are responsible for ensuring students remain calm and orderly, lining up to exit through the nearest emergency route towards the assembly area. Teachers are the last to leave the classroom, ensuring lights and fans are switched off, and they carry the attendance book to verify student presence at the assembly area. Missing students are reported to the relevant

authorities. Similarly, students, upon hearing the bell, should maintain composure and adhere to their teacher's instructions. They must form lines, follow the teacher to the designated exit, and subsequently to the assembly point. The priority is not to leave any classmates behind. Upon reaching the assembly area, students should gather as instructed and notify their teacher of any missing individuals. Both teachers and students should remain in the assembly area until further announcements. Challenges arise due to the inadequate comprehension of fire situations among school students. Replicating genuine fire emergencies during drills is complex and potentially hazardous, hampering the effectiveness of fire drill simulations, particularly for younger students (Moreno-Ger et al., 2012). To address this issue, one proposed solution is the development of a digital simulation game for fire drills (Spiegel & Hoinkes, 2009). Such a game would offer students a realistic experience of evacuating a building amidst an ongoing fire, potentially enhancing their preparedness.

Simulation Games and Its Category

Simulation games can be seen as a fusion of diverse gaming skills, opportunities, and strategies that give rise to intricate game structures (Moreno-Ger et al., 2012). Additionally, simulation games belong to a genre that seeks to replicate and emulate real-world situations. These games have found application in education due to their capacity to immerse players in decision-making exercises within artificial environments, enabling them to grasp the repercussions of their choices. Moreover, simulation games have been recognized for enhancing student motivation, leading to a deeper engagement with the training material. Simulation games can also fall under the serious game category, which prioritizes specific purposes like education, military training, and healthcare over pure entertainment (Spiegel & Hoinkes, 2009).

There are several categories of simulation games each serving distinct purposes. The first type is Participatory Simulation Games, wherein players physically engage in the game's environment, often executing fictional actions as part of the gameplay, often utilizing technologies like virtual reality (VR) or augmented reality (AR) (Moreno-Ger et al., 2012). The second type is Iterative Simulation Games, designed to progressively construct an outcome, such as a business model or computer simulation module. This involves introducing individual known variables one after another to observe the resulting impact (Soewardi & Perdana, 2019). Another category is Procedural Simulation Games, which replicate real-life action-consequence models. These simulations guide players through processes using provided procedures, making them especially suitable for vehicle-related simulations (Moreno-Ger et al., 2012). Lastly, there are Situational Simulation Games, focusing on models that emulate behavioral and emotional responses within various scenarios. Typically, these simulations are confined to player characteristics' behavior. However, the advent of advanced artificial intelligence systems in intricate environments prompts the inclusion of human, computer, and player characters in Situational Simulation Games (Soewardi & Perdana, 2019).

Based on simulation games characteristic, the procedural simulation game is suitable for the fire drill simulation game due to this game will follow the procedure of the real fire drill simulation.

Method

Game Development Life Cycle

This methodology allows a more effective way of flexibility to make a change during the development process of the game. This methodology also provides the quality criteria of the

prototype stage to keep the quality of the outcome or product (Ramadan & Widyani, 2013). This methodology consists of six phases of development process such as initiation, pre-production, production, testing, beta, and release. In this project, the phases will stop at the Testing phase to see its functionality and usability before being released to beta and public users.

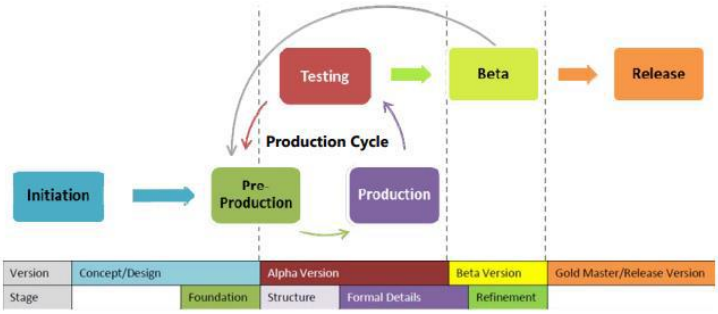

Figure 1: Game Development Life Cycle (GDLC) phases

The commencement stage marks the initial step, aimed at conceiving the core idea for the intended game development. Here, the fundamental concept and gameplay mechanics of the game are outlined. The setting of the game is envisioned within the confines of a school building. During the pre-production phase, the game's progression is planned, ensuring players encounter a fire drill scenario that necessitates building evacuation. Subsequently, in the production phase, the entire development process adheres to the predefined game concept and design established in the preceding phase. Moving on to the testing phase, a prototype of the game is crafted and subjected to user testing to gauge its functionality. Once the prototype is successfully constructed, it undergoes multiple rounds of testing to assess its performance. A usability test is employed to identify both minor and major flaws within the game that could impact the user experience. The primary aim of this rigorous testing regimen is to uphold the game's quality standards.

Results

Simulation Games

Firstly, a three-dimensional (3D) modelling is done to create the character model, school building and environmental objects in school. Example 3D models are shown in Figure 2.

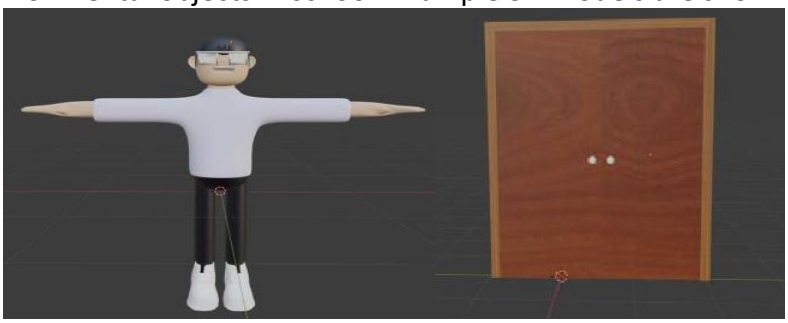

Figure 2: 3D model of character and school door objects.

Next, the model is then animated into 3D animation to give the illusion that these digital objects are moving through 3D space. Then, a graphical user interface is created to navigate users throughout the game before the main menu, tutorial and gameplay scene is created into scripts and built into windows.

Figure 3: A main menu for the game.

When the game started, the users are given some situation where the fire happens in the school building and there are missions given to the users to escape the fire from the building. Users need to navigate the main characters and avoid the fire and follow the correct path to the assembly point in the main scene.

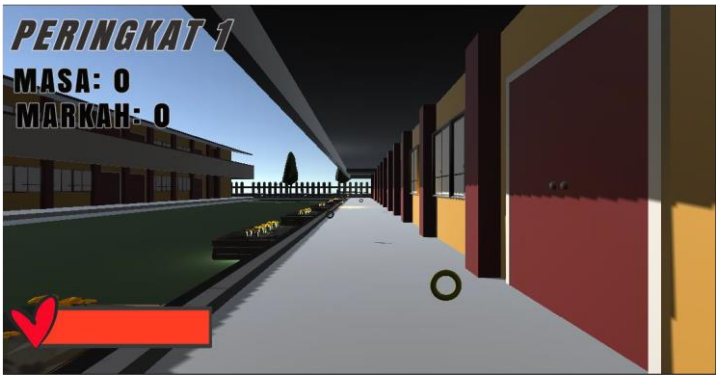

Figure 4: The game scene where the time left, live and score are shown in the interface to guide the user to escape from the fire.

The game encompasses three distinct phases, requiring users to guide players to the designated assembly point, steering clear of fire-prone zones and obstacles obstructing the path. Subsequently, users are educated on distinguishing among various fire extinguishers designed for specific fire types that could potentially occur within the premises. The final phase instructs users on how to extinguish small fires in accordance with guidelines from FRDM. Upon completion of each stage, users receive informative insights about fire risks, enriching their understanding as depicted in Figure 5.

Figure 5: Do you know section where valuable information regarding fire hazards is given to the users when the stage is cleared.

Evaluation Phase

Usability Testing

The objective of this usability test is to confirm that the game's educational content meets user satisfaction and is user-friendly. The test also aims to verify the game's functionality for users. A group of 12 students, comprising six boys and six girls aged between 10 and 12, was selected from a nearby school to ensure the success of this testing process. Prior to commencing the usability test, the game was installed on a personal computer for participants to take turns using. The participants were not required to set up the game themselves, as the tester had already configured everything. Before initiating the usability test, participants were provided with an explanation of the test procedure and briefed on how to navigate and engage with the game. This pre-testing information ensured that participants were well-informed about the process and the game, facilitating a smooth testing experience.

Throughout the testing, participants were tasked with completing all stages implemented in the game. The tester only observed and refrained from assisting participants in completing the game. Once the participants finished all three stages, they were instructed to halt their gameplay. Following this, participants were asked to express their feelings about the game, and a usability questionnaire (depicted in Figure 6) was administered to gather their feedback.

Questionnaire	Likert Scale				
	1	2	3	4	5
1. I am not bored to play Escape From Fire over and over again.					
2. I think Escape From Fire is a game that is hard to play.					
3. This game is easy for me to use.					
4. I need the help of others to play Escape From Fire.					
5. I feel that this part of Escape From Fire played well.					
6. I feel that this way of playing Escape From Fire confuses me.					
7. I think other people will learn to play Escape From Fire quickly.					
8. I feel that Escape From Fire is not practical (difficult) to play.					
9. I feel like I can play Escape From Fire.					
10. I have to learn a lot of things to play Escape From Fire.					

Figure 6: System Usability Scale (SUS) questionnaire.

Table 1 shows the calculation of the data using the System Usability Scale (SUS). The total of respondent Score Values for this usability test is 840.

Table 1
The SUS result from the test.

Respondent Number	Item Question										Total	SUS Score (Total * 2.5)
	1	2	3	4	5	6	7	8	9	10		
1	4	0	2	2	3	2	4	0	2	0	19	47.5
2	4	3	2	2	2	2	1	3	2	1	22	55
3	4	2	0	3	2	3	0	0	4	4	22	55
4	4	3	4	3	3	2	3	3	3	2	30	75
5	4	2	4	2	3	3	3	1	2	4	28	70
6	3	2	2	2	3	2	3	1	3	3	24	60
7	4	4	4	3	4	4	4	4	4	3	38	95
8	3	2	1	2	3	2	3	3	3	3	25	62.5
9	3	4	3	4	2	3	4	0	4	4	31	77.5
10	3	2	3	2	3	1	4	1	4	2	25	62.5
11	4	3	4	4	4	3	4	3	4	3	36	90
12	4	2	3	4	4	3	4	4	4	4	36	90
TOTAL												840

To calculate the average value of this data is by using the second formula which is the Respondent Score Value divided by the Number of Respondents. Therefore, the value of the average is 70. Based on (Will T, 2021), an SUS score above a 68 would be considered above average and anything below 68 is below average. Hence, this concludes that the game is considered above average.

Conclusion

To sum up, the "Escape from Fire" game is fully operational and playable. While certain participants faced challenges due to their lack of experience with personal computers, they eventually overcame these difficulties and successfully completed all game stages independently. They also concurred that the game significantly enhanced their understanding of fire drills and how to respond to prolonged school bell ringing. All research objectives have been achieved. The simulation game has been effectively developed, although with some imperfections, offering an innovative approach to educating primary school students about fire drill procedures is what is stressed in this research. Though certain limitations, such as compatibility only with personal computers and single-player mode, there is optimism for future enhancements, including the development of an online multiplayer platform. Crucially, students gained fundamental awareness of fire hazards and proper responses through this game. This success underscores the potential of digital games as an alternative educational method.

In addition to the successful development and implementation of the "Escape from Fire" game, this research has made significant theoretical and contextual contributions to the field of education and fire safety awareness. The significance of this research lies in its innovative approach to educating primary school students about fire drill procedures through digital gaming. While traditional methods of fire safety education have been widely used, this study introduces a novel and engaging way to impart crucial knowledge to young learners.

The theoretical contribution of this research is evident in its exploration of the potential of digital games as an alternative educational method. By harnessing the immersive and interactive nature of gaming, this study demonstrates how it can effectively enhance students' understanding of fire hazards and appropriate responses. This theoretical insight

expands the horizons of educational methodologies and suggests that gamification can be a powerful tool in imparting important life skills.

Contextually, this research addresses the pressing need for comprehensive fire safety education in primary schools. Fire incidents in educational institutions can have devastating consequences, and this study provides a proactive solution to mitigate these risks. By offering a digital game that can be accessed on personal computers, it caters to the technology-driven learning environment of today's youth.

Furthermore, the research highlights areas for future enhancement, including the development of an online multiplayer platform. This forward-looking perspective demonstrates the adaptability and scalability of the "Escape from Fire" game, making it relevant not only for current primary school students but also for future generations.

In conclusion, this research not only achieves its immediate objectives by successfully developing and implementing the "Escape from Fire" game but also makes significant theoretical and contextual contributions to fire safety education. It emphasizes the potential of digital games as an innovative educational method and addresses the need for proactive fire safety education in primary schools. This research's forward-looking approach ensures its continued relevance and impact in the field of education and fire safety awareness.

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