ISSN 2278-3091
Volume 9, No.4, July – August 2020
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse253942020.pdf
https://doi.org/10.30534/ijatcse/2020/253942020

Development of Virtual Reality Training for Fire Safety Education

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ABSTRACT

Recent technology of education has been using software, hardware, and educational theoretic to facilitate the learning process and improving student's performance. For example, Virtual Reality (VR) is one technology that helps the user to be focused on the learning content that they see. In getting people's attention to be alert and aware of the need and how to use a fire extinguisher, an application using VR technology has been developed. This application has given a basic exposure to fire safety and fire drill to the users. Through the usability testing investigation, the results on using VR fire extinguisher received more than 80%, indicating that the application manages to give awareness to users on the needs and steps to use a fire extinguisher to extinguish the fire. Comments and recommendations from experts have been given more ideas in order to improve the application as well as upgrade its' quality in the future.

Key words : Fire Extinguisher, Awareness, Virtual Reality, Development.

1. INTRODUCTION

The recent technology of education has given great exposure to people in getting clear information, better compared to the traditional approach. The traditional approach is normally giving lectures and not everyone is good at getting people's attention to listen until the last word. Nevertheless, recent technology of education has been using software, hardware, and educational theoretic to facilitate the learning process and improving student's performance by creating, using, and managing appropriate technological processes and resources. Some examples are such as gamification, social network, smart whiteboards, smartphones, augmented reality, VR and so on.

VR has given a different, innovative education system where students can be immersed in the information that can facilitate their learning [1]. VR methods allow a new intuitive way of communication between human and machine. The basic idea of this technology is the user not only can look at but also can interact with actively using data glove and data helmet[2]. Hu-Au and Lee [3] stated that VR leads to increase student engagement, allowing constructivist learning, providing authentic experiences that impact the student's identity, affording new perspective, improving empathy, and promoting creativity and the ability to visualize difficult models. The concept of VR in Edutainment promotes a controlled, realistic supported learning that allows thoughtful and cautious management by students in possible real situations [4] and becomes an interactive learning tool that aims to educate students with good problem-solving skills and encourage creativity [1].

Another study by [5] emphasizes that the virtual environment provides maximum experimental control, is easily replicated, has relatively high ecological validity, and allows the study of occupational behavior safety in scenarios that would otherwise be too dangerous. Their research study analyzes the Strengths, Weaknesses, Opportunities, and Threats (SWOT) of VR for fire evacuation.

VR can be defined as a 3-D user interface in which user can perform actions and experience their consequences [6]. The VR can be considered as a multidimensional real time simulation rather than a linear animation with predefined camera movement. This distinguishes VR from recorded, computer generated, images used in films and on television and from real-time computer animation where the user is a passive viewer. This benefits the VR user as the technology allow user to move around freely in a virtual environment, unlike pre-rendered images of a 3D environment.

Meanwhile, according to Brushlinsky, Ahrens, Sokolov, and Wagner [7], Central Technical Interception Facility (CTIF) report, every year there are many fire accidents, resulting in a great loss of property and life. Thus, people should have the awareness of the fire extinguisher usage and the steps that should take when the accident occurs. In the current approach, explanation in delivering the use of fire extinguisher to students and staff in UTeM is still considered as a traditional approach as the fireman will give an explanation outside the building with gathering people.

Unfortunately, despite that the information is important, most people feel bored since not everyone got the chance to practice using the fire extinguisher and some prefer their own chatting story compared to learn about the use of fire extinguisher. From that fire drill session, not everyone can try to extinguish fire using the fire extinguisher. Furthermore, the fire drill session is just once a year because it consumes a lot of expenses and time. As a result, the briefing objective by the fireman did not achieve and most people still had less awareness of using fire extinguisher due to certain reason.

In getting people's attention to be alert and aware with the need and how to use a fire extinguisher, an application using VR technology have been developed in order to get some information and train themselves for a fire accident situation by using the fire extinguisher. The VR technology has been chosen as it is one of the technologies that have been growing in the use of smartphone for now and the VR devices are affordable to buy. These advantages are due to devices becomes cheap to get and the functionality is combined with a smartphone and the VR device, especially youngsters such as university students.

VR presents an effective way to transport audiences to destinations on land, sea, or in the air without having to leave their chair [8], as it may provide the future educational field trips and can be implemented into programming. Through community partnerships, educators can develop VR videos to educate youth on any discipline to their community.

In supporting any higher levels goals, realism in virtual environments as highlighted by [9] requires significant role such as user training or accessing user awareness, especially in hazardous situations. In addition, as for important places as such fire placement, exit routes and crowd behaviour, the context of fire drills shall include realism requirements in (i) the built environment, (ii) the behaviour of the fire and smoke and (iii) the features of the scenario.

Therefore, development of VR application is the best choice to give awareness to public as well as overcome the fire accidents. The goal of implementing usability testing is to have a better understanding of how real users interact with the product in which later it can be used to improve the product based on the results. This also highlighted by Dumas and Redish [10] stating that a usability test is considered successful only if it helps to improve the product that was tested and the process by which it was developed

2. RELATED WORKS

Nowadays, the practices on safety and health becomes very more important to all industry especially in the manufacturing industry [11]. According to Khdair, Shamsudin, and Subramanim [12], safety at work is difficult and a complex phenomenon and the subject of safety performance across the industries is hard and challenging to be achieved as it needs a lot of measures and policies to be applied. Moreover, safety performance is a very complicated and sensitive concern of the organization to deal with, as it is the matter lives of people and resources, and who involved in the project towards success.

Another reason for implementing the effective management of health and safety is about the financial costs of a crash[12], where business interruption can be as one of the costly portions of a major emergency. These issues may even be a problem with relatively small emergencies if the fire has shut down a critical part of the facilities operations [13]. For ethical and safety reasons, fire safety education relies more on providing written or oral information to consumers on how to respond to such situations despite the fact that such an approach provides little motivation or engagement, especially to young audiences, large awareness populations. and fire safety education are also often targeted [14].

Table 1: Statistical Information of Death And Injury Cases

STATE	FIRE CASES	DEATH CASES	INJURY CASES
SELANGOR	7,345	14	68
JOHOR	4,928	11	54
PERAK	3,863	16	22
KEDAH	2,493	7	24
SABAH	2,475	14	24
SARAWAK	2,377	10	37
PULAU PINANG	2,203	3	31
PAHANG	2,163	5	21
NEGERI SEMBILAN	1,967	3	24
TERENGGANU	1,623	1	11
MELAKA	1,561	3	34
W.P. KUALA LUMPUR	1,561	7	29
KELANTAN	1,325	1	13
PERLIS	556	1	5
W.P. LABUAN	221	1	0
W.P. PUTRAJAYA	97	0	0
TOTAL	**36,758**	**97**	**397**

Resources : Jabatan Bomba dan Penyelamat Malaysia[16]

An interesting involvement for awareness for preschool, [15] has claimed unsuitability of training on how to use fire extinguisher and has suggested the improvement of fire safety education to spread fire safety awareness among preschoolers and teachers.

Table 1 display statistical information about death and injury cases due to fire cases in 2018[16]. Despite that, there may be fewer cases compared to previous years, but the fire and injury cases are still high. From the data are shown in Table 1, it is predicted that if a lot of people been given

awareness and know-how to use fire extinguisher been given, the number of death and injury cases will be reduced.

Despite the impact from the data shown in Table 1 relates to the loss from all states in Malaysia, study by [17] state that important lessons from this incident can also be learned, increasing understanding of how fires evolved in historical structures and why they occurred in the first place. This also shows that awareness on the use of fire extinguisher is important to prevent big incident happen, in which it should also being taught among young generation for them to always being alert from creating fire incidents.

3. MATERIALS AND METHODS

In this section, a description of the product development is presented. This application shall provide a training session and a situation where the individual need to extinguish the fire with the fire extinguisher with the steps provided. Besides that, there will be an instruction room which each individual needs to go through before entering the training session as guidance.

The Agile Model was used as the methodology since it provides multiple opportunities for developers before, during, and after each phase[18]. The benefits of Agile methods can help teams manage work more efficiently and do the work more effectively while delivering the highest quality product within the constraints of the budget[19]. By involving selected users in which during this development involved stakeholders such as multimedia lecturers and firemen, it will provide more opportunities for the user to truly understand the vision of this development. In addition, agile methodology also benefits as its practices have been defined, of which the most popular are daily review meetings, short iterations, and prioritized backlogs[20].

In the development process of VR for Fire Extinguisher, some software is needed to complete each task such as for illustrating, design instruction, design each room and 3D model for objects. The benefits in using 3D model as mentioned in [21], it provides an environment that allows learning process personalization and enhances learner awareness of the acquired learning skills. On software requirements, Adobe Illustrator and Photoshop have been used to design instruction and information in the application, Autodesk 3ds max being used for designing 3D modeling for the application and the VR were designed by Unity in which later it and will build as an application (.apk) which support android smartphone.

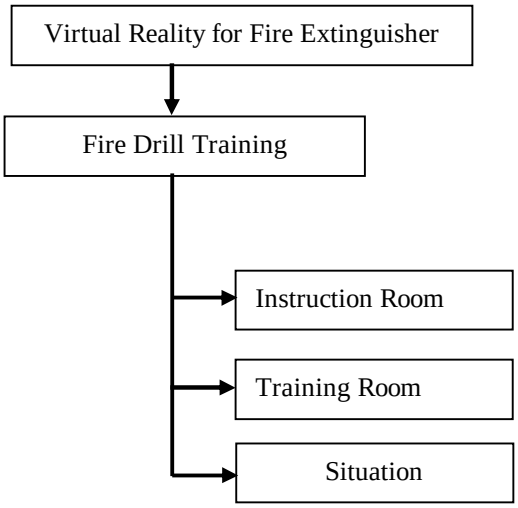


Figure 1: Content Analysis of study

VR technology is using the virtual devices as an output medium. The application is provided with multimedia elements for VR technology. In the application, VR will display information about fire extinguisher, steps need to be taken if there is a fire accident and how to use fire extinguisher. All this content shown in Figure 1 and the functions will be developed by using Adobe Illustrator, Adobe Photoshop, and Unity.

The VR device is the medium to deliver the things that have been designed via the VR application. There will be three rooms and each room have their own function which user will explore it and get the experience. Figure 2 display the platform design of Unity for an instruction session. Meanwhile Figure.3 – Figure.5 display example of designs consisting of the virtual environment design.

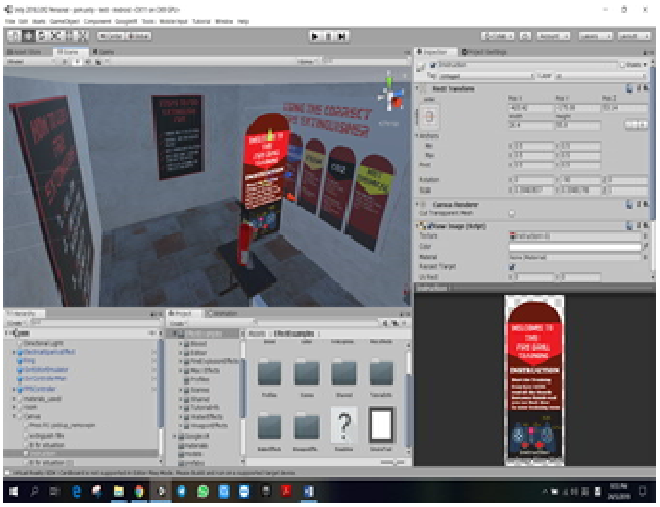


Figure 2: The Platform design of Unity for instruction session

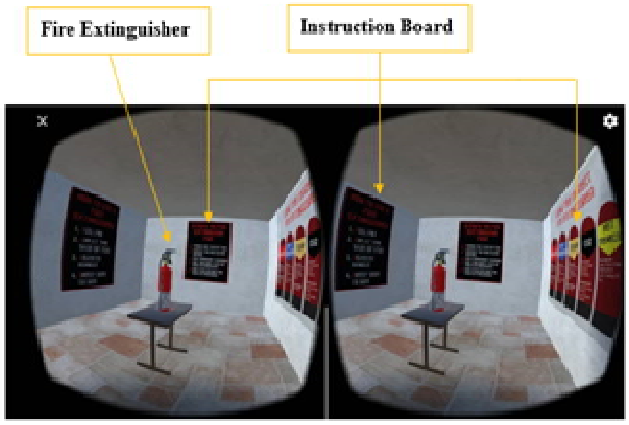


Figure 3: The Instruction Room

The first room contains all the information and steps about fire safety. While the second room contains the 3D models for a fire extinguisher and other objects. In addition, the room also trains the individual to trigger the fire alarm and extinguish the fire. Besides that, another room will have the time for the individual to extinguish the fire within a few seconds. If the player failed to complete the task before the setting time, the situation will start from the beginning. There also have a line for the player which if the player crosses the line the player will start from the beginning of the situation to aware the player to not get near the fire. This also shows that user should be alert when extinguishing fire, there is a set distance from the actual fire.

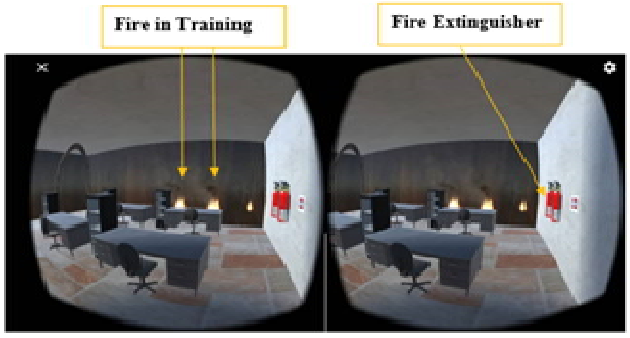


Figure 4: The Training Room

The instruction room as displayed in Figure 3, presents the instruction board containing steps and information regarding fire extinguishers and how to use the application. Meanwhile, Figure 4 displays the design environment of the training room, which helps the user to be familiarized with the instructions step when using the fire extinguisher to extinguish the fire. The Figure 5 display a situation environment in which users have to extinguish the fire within a limited distance area in a very shorten time. There were three rooms and each room have their own function which user will explore it and get the experience. Despite that, the design environment shown in this section are very basic, but at least it shows the minimum requirement for a user to have some awareness regarding fire extinguisher.

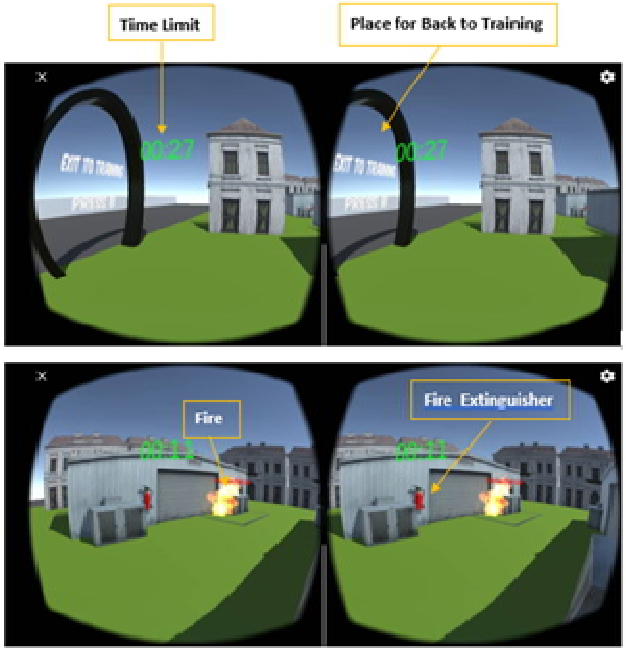
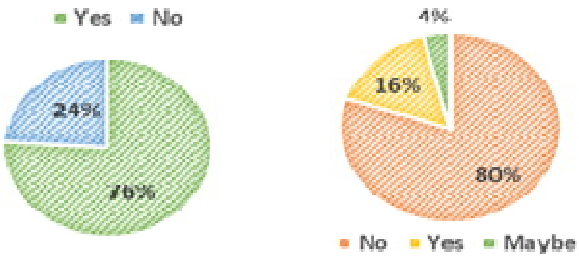


Figure 5: Situation Environment

4. RESULTS AND DISCUSSION

The target of this study was also to provide contributing factors of VR application in student learning with the hope in enhancing student's confidence, being motivated, memory to learnt concept, and able to communicate the content easily[22]. Based on preliminary analysis, finding as shown in Figure 6 presents (a) information regarding people's preferences on using VR as compared to traditional approach and in (b) presents the percentage of people's knowledge on the existence of VR fire extinguisher. From Figure 6(a), the result shows that 76% over 50 people prefer learning fire extinguisher using VR technology compared to traditional way, while Figure 6(b) shows 80% over 50 people never heard about VR fire extinguisher. Due to this result, it gave us an opportunity to develop an application that helps people on awareness of fire extinguisher using VR.



(a) Learning Preference Using VR Fire Extinguisher (b) People's Knowledge on The Existing VR Fire Extinguisher

Figure 6: Preliminary analysis on VR Fire Extinguisher

Table 2: Alpha and Beta Testing summarization

	Alpha Testing	Beta Testing
Testing Type	Functionality a. Learnability. b. Effectiveness of multimedia elements used. c. Ease of use of button and control.	User Acceptance a. Usability of the product. b. Awareness level of the product.
Data Collection	Interview and Questionnaire	Questionnaire and Observation
Type of respondent	Expert gaming multimedia and fire/safety operation background	Other background respondents
Number of respondents	3	20

As mentioned earlier, the testing phase is the last phase in agile methodology for the development of fire extinguisher awareness using VR. To view the usability testing, there were 2 types of testing being used which were the alpha testing and beta testing. Alpha testing is performed before releasing the full operating product to identify all possible problems. The purpose of this test is to guarantee the performance and operation of the product as expected.

Table 3: Alpha Testing Results

Task Description		Median Score each question	Median Score each part
A. Learnability			4
1	User instruction in the application is easy to understand.	3	
2	The content of the VR for Fire Drill application is easy to understand.	4	
3	VR for Fire Drill application was very helpful to learn about fire safety.	5	
B. Effectiveness			4
4	Integration of multimedia elements in the content helps user to receive the information effectively.	4	
5	The content arrangement makes the delivery of information more effective.	3	
6	The application able to give an impact to the user.	4	
C. Ease of Use			4
7	This application is easy to use.	4	
8	Readability of text is clear, and the objects are realistic as actual environment.	5	
9	The sensitivity of the application is good and accurate.	3	

Meanwhile, beta testing is carried out in a real-time setting by the true target user where it will be introduced when it is completely operating. Beta testing is performed to get feedback from the actual customer to reduce the risk of product failure and boost the actual product quality. During the beta testing, we tested among experts gaming multimedia lecturers and the fireman as he becomes an operation background fire and safety expert. Table 2 displays the summarization of the testing phase involved in this development.

For the alpha testing, all respondents need to operate the fire extinguisher in the VR environment. The multimedia expert will evaluate more regarding the multimedia and gaming elements involved in the application while the firemen personnel will evaluate the operational when handling the fire extinguisher in the VR. The specific questionnaires distributed to them and the result analyzed as shown in Table 3.

Table 4: Beta Testing Results

TECHNICAL ASPECT OF THE PROJECT	Male		Female		Total	
	Yes	No	Yes	No	Yes	No
Do you understand the instruction of the VR for Fire Drill application?	8	2	6	4	14	6
Do the environment of VR for Fire Drill application is suitable?	7	3	6	4	13	7
Are the music and sound use in VR for Fire Drill application is suitable?	8	2	9	1	17	3
Are the image and 3D models use in this application helps to understand better about this awareness?	8	2	7	3	15	5
Does the size and font of the text used in this application is suitable and clear?	6	4	7	3	13	7

EFFECTIVENESS OF THE CONTENT	Male		Female		Total	
	Yes	No	Yes	No	Yes	No
Do you understand what the awareness is about from this application?	7	3	9	1	16	4
Does this awareness give you any new knowledge or detail that you didn't know before?	6	4	6	4	12	8
VR for Fire Drill training enhances teaching and learning for fire safety.	9	1	7	3	16	4
Does the awareness have any effects on you?	8	2	9	1	17	3
In your opinion, do you think this method (VR for Fire Drill) is more effective to use in an awareness better than old method (Traditional fire drill)?	7	3	9	1	16	4
VR for Fire Drill application is useful to me.	8	2	7	3	15	5

From Table 3, in terms of functionality, the operationalizing of real fire extinguisher is good with the median score of 4 (Agree). This result was taken from the experts from a multimedia background and from the fireman personnel. In addition, comments and suggestions also received from the experts for the next improvement as shown in Table 4.

Beta testing had been done by 20 respondents consist of both gender male and female. The average age of the respondent is about 22-year-old which is majority the generation Z. The questionnaire is distributed to this respondent after they have finished using the VR application to operate the fire extinguisher in order to put off the fire. The analysis had been made based on the result required by the questionnaire and results were shown in Table 4.

The beta testing was the usability testing of the VR technology as respondents were instructed to use the VR box to test the application. Once finish the test, respondents were required to answer the closed-ended questionnaire focusing on the acceptance of the technology as shown in Table 4. The questionnaires of beta testing were divided into the technical aspect and of the project and the effectiveness of the content.

The results for questionnaire 1) Do the awareness have any effects on you? and 2) Are the music and sound use in VR for Fire Drill application is suitable? , have been agreed by 17 users giving 85%. The following questionnaire 1) Do you understand what the awareness is about from this application? 2) VR for Fire Drill training enhance teaching and learning for fire safety and 3) In your opinion, do you think this method (VR for Fire Drill) is more effective to use in an awareness better than traditional method, have received 80% as 16 over 20 students agreed with these questionnaires. In general, based on results shown in Table 4, the beta testing carried out during the testing session can be concluded that the overall respondent satisfied with the VR application.

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4 CONCLUSION

VR for Fire Extinguisher has given a basic exposure about fire safety and fire drill to the users in UTeM. Through the usability testing investigation, the results on using VR fire extinguisher received more than 80%, indicating that the application manages to give awareness to users on the needs and steps to use a fire extinguisher to extinguish the fire. Comments and recommendations from experts have been given more ideas in order to improve the application as well as upgrade its' quality in the future. The improvement later in the future product hopefully will become better in which it will help to give awareness and educate people in experiencing the fire extinguisher using a VR concept in which the user will be able to manage the fire extinguisher ready to be used at any time to prevent risk.

5 FUTURE SCOPE

The VR technology has become an interesting learning support in the Fire Extinguisher Maintenance System. Nevertheless, for future improvement, user may have to declare themselves as novice or amateur gaming player before they start using this system. For novice, since they may be very new in using VR technology, their time on trying out this system should be a given extra time due to the constraint of using new technology. In addition, different and challenging situation environment should include more to let amateur enjoy using this system.

6 ACKNOWLEDGEMENTS

The authors would like to express appreciation for supports provided by all those involved either directly or indirectly in the completion of this paper especially to Centre for Advanced Computing Technologies (C-ACT), Optimization Modelling Analytic and Simulation (OPTIMAS), Pervasive Computing & Educational Technology (PET) and Faculty of Information Communication Technology (FICT), and also Centre for Advanced Research on Energy (CARe) and Faculty of Mechanical and Manufacturing Engineering Technology, Universiti Teknikal Malaysia Melaka (UTeM).

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