A GAME-BASED INTERACTIVE TRAINING SYSTEM FOR IMPROVING THE ENGAGEMENT OF HAZARD LEARNING AND TRAINING

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ABSTRACT

Natural Disasters, events that are frequently occurring around the world, taking away homes and innocent lives within minutes or even seconds with the only goal of destruction. Only when we see it on the news of fatalities around the globe when we realize how fragile human life is. The most concerning problem is that current disaster training procedures are not sufficient in preparing the general public in the case of natural disasters such as earthquakes which can wipe out thousands of homes and cause massive casualties if not properly prepared for. To address this situation, the first prototype that we came up with was the Safety Lifetime earthquake simulation game. We believe simulation-based learning would be better at covering more information as well as making the lessons more memorable. As a prototype, Safety Lifetime only contains the simulation of a real earthquake, and lessons to guide the user through what to do during an earthquake, what items to collect, what is the safest sheltering location, and more. In order to verify the effectiveness of the training system, we performed a small-scale user study. 10 users are divided into two groups. Group A is given the booklet earthquake educational materials, while Group B is provided with the game system. Each group spends 10 minutes to learn the content, followed by finishing a quiz. The result shows that the average score of the Group A is 8.5/10, while the average score of the Group B is 9.3/10.

KEYWORDS

Disaster training, earthquake, simulation-based learning, training system.

1. INTRODUCTION

There have been cases of extreme natural disasters that have happened throughout the years. Here we take Earthquake as an example as they are the most prominent threat in California. At least 369 people die - most in and around Mexico City - during a magnitude 7.1 earthquake in 2017. in 2018, more than 460 people are killed after a 6.9 magnitude earthquake hit the Indonesian island of Lombok [3]. It leveled homes, mosques, and businesses, displacing some 350,000 people. In the United States, the infamous San Francisco Earthquake in 1908 caused more than 3000 death Only when we see it on the news of fatalities around the globe when we realize how fragile human life is. This year started with dramatic events such as kobe's unfortunate death, the coronavirus, and the rumors of a world war which really makes you wonder how life could be gone in an instant, which will change everything. Natural disasters, like earthquakes, are sudden and almost unpredictable, so it is good to always take precautions and be prepared for when these events strike. However, the central problem of this is the lack of natural disaster survival

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education. As reported in a FEMA survey in 2015, nearly 60 percent of American Adults have not participated in natural disaster training [1]. This is even more detrimental when considering that 80 percent of Americans live in counties that have been hit by a weather-related disaster since 2007 as reported by the Washington Post in 2018 [2]. The people in high rate earthquake countries like China and Indonesia almost have no access to education about these natural disasters, which is the reason why this simulation/program would serve as a protection and education for the safety of these individuals [14].

Natural disasters are extremely dangerous and have devastating effects, especially on those who are inadequately prepared [4] [5]. Currently, for most adults, earthquake and natural disaster training systems present the survival information in a word-based format such as websites and booklets or in a video and lecture-based format as seen on YouTube and television. The first practical problem with current disaster training systems is the lack of coverage as few American would actively seek out the information online if it is not directly presented to them. In addition, it must be recognized that text-based learning is not effective at conveying large quantities of information in a concise or enjoyable way. Though readily accessible, the long articles and texts on the many websites are often complemented by very few pictures in between and may discourage learners to read through information in its entirety. This will lead to a less comprehensive and potentially flawed understanding of the earthquake survival process. As a result, the learner may struggle to recall much of the information presented due to the lack of constant learner engagement. Though video-based learning addresses some of the flaws mentioned above, it is still problematic as most videos only explain a part of earthquake survival but do not present the information regarding earthquake survival in a holistic manner. In addition, the lack of learner engagement remains problematic with video-based learning as well. The reality is that people are not educated to face any of these devastating events, nor have an understanding of what to do during situations of a disaster under the current system.

In this paper, we utilized Unity and visual studios to create a game like simulation on earthquake and added in the lessons, with audio recording and quizzes at the end for the users to take so that they have understood the material they have learned in each lesson [6] [7] [11]. Our goal in creating this project is to introduce earthquake survival knowledge in a more concise and interesting way by presenting them in the form of a game. In order to verify the effectiveness of our simulation-based training system, we performed a small-scale user study. We selected 20 users of similar educational background. The 20 users are divided into two groups. Group A is given booklets of earthquake educational materials, while Group B is provided with the game system, Safety Lifetime. Each group spends 10 minutes to learn the content and is asked to finish a quiz at the end of the 10-minute studying period. The contents of the quiz are all covered in the booklets and the simulation, and none of the questions overlap with the questions that were part of the simulation. The Quiz taking environments are the same, and all communications or outside interference have been monitored and deterred. The result shows that the average score of Group A is 8.5/10, while the average score of Group B is 9.3/10. This 0.8 difference is quite significant as this is only a ten-question quiz, and there is an eight percent increase in two groups of people with very similar educational backgrounds. However, this result cannot definitively prove the simulation's effectiveness as slight variations in the subjects' inherent earthquake survival knowledge can have a noticeable impact in a small subject pool. The subjects from Group B may have another advantage. The quizzes within the simulation may have better prepared them for the test quiz given to them at the end of their 10-minute studying period. Nonetheless, the simulation was able to achieve our initial goal for the project. It seemed to be effective at educating the test groups as it presents a more engaging game-based learning method. Its true effectiveness can be proven upon more comprehensive testing with bigger subject groups chosen specifically for their similar level of earthquake survival knowledge before the experiment.

The rest of the paper is organized as follows: Section 2 explains the challenges we faced in designing our prototype; Section 3 further elaborates on the simulation's design process and creation as well as giving further details regarding specific components of the simulation; Section 4 explains the details regarding our experimentation; Section 5 presents the related works on this topic, some of which inspired the creation of this project. Finally, Section 6 gives the concluding remarks, as well as elaborating on future developments of this project.

2. CHALLENGES

There are a couple of challenges in the project. They will be discussed one by one in this section.

2.1. Challenge 1: The Differences in User Platforms.

In order to further spread awareness and educate people on natural disasters survival, it is important to make our simulation and game accessible to as many people as possible. It is difficult to make the simulation and game compatible with the vast variety of platforms that the user may wish to use. Some of the simulations and games may need to be reprogrammed to be compatible to different platforms but this remains an issue we will focus on later in the project's development.

2.2. Challenge 2: The Difficulty to Give Important Additional Information to Users.

The purpose of our simulation and game is to present more interactive and educational lessons on natural disaster survival. However, immediately we realized that California does a fairly good job on public education regarding earthquake survival, our primary objective of interest. Everyone in California and most likely in the United States will have some basic knowledge on the concept of duck and cover. Though there is some additional information involved with earthquake survival, many of them are merely suggestions that will not significantly enhance the users' chance of survival. Inclusion of those insignificant details will only distract the user of the essential ideas behind earthquake survival. In short, to develop our intended lessons, we aim to add important additional information to enhance the prevalent lessons on Earthquake survival while simultaneously avoid overloading the users with information. We realized that current Earthquake lessons only focus on the things to do during an earthquake and not so much before or after. The methods of Earthquake preparations are often tedious and difficult for users to remember from traditional lessons. As a result, we chose to develop a three-staged lesson with additional emphasis on the essential safety procedures before and after the Earthquake. In doing so, we hope to present a more complete and interactive lesson of the necessary procedures in Earthquake survival.

2.3. Challenge 3: The Difficulty to Set Up Complex Branching Pathways in the Game.

Currently in the game, one must complete all the tasks in the game in order to proceed to the other lessons. While this serves our purpose in reinforcing the lessons we gave previously before the simulation, this does not seem to be an accurate reflection of the sequence of real-life events. For example, not bringing bandages in the survival kit does not prevent the earthquake from happening as it does in the simulation when it prevents the lesson's progression. However, in real life, the lack of bandages increases one's risk for infections after the Earthquake which the simulation does not show. In conclusion, while our first prototype gives the user a better knowledge in the complete procedure of earthquake survival, it does not adequately show the reason behind the actions in procedure. Thus, this problem may negatively affect the effectiveness of the simulations in making the lessons more memorable. This is a problem we will later address as we introduce more complexities into our prototype.

3. SOLUTION

3.1. Overview of the Solution

Safety Lifetime is a game-based learning system created through Unity using a C# Script [12] [13]. Our method is inspired by the introduction of simulation-based learning in colleges and medical programs as they have shown to be more effective than more traditional styles of learning. In this simulation, we ask the learner to apply basic earthquake survival knowledge they learned into situations of realistic scenarios during a real earthquake. The first lesson and simulation would be what to do before an earthquake happens, and what items to pick up that will be best in that situation. The second lesson focuses on during the earthquake, including where the best places for hiding are, and the best shelters. The third will be around after the disastrous event, what to do and where the safest place is. In doing so, we also hope to address the lack of consistent learner engagement seen in current earthquake survival training programs, and therefore make the lessons more interesting and memorable.

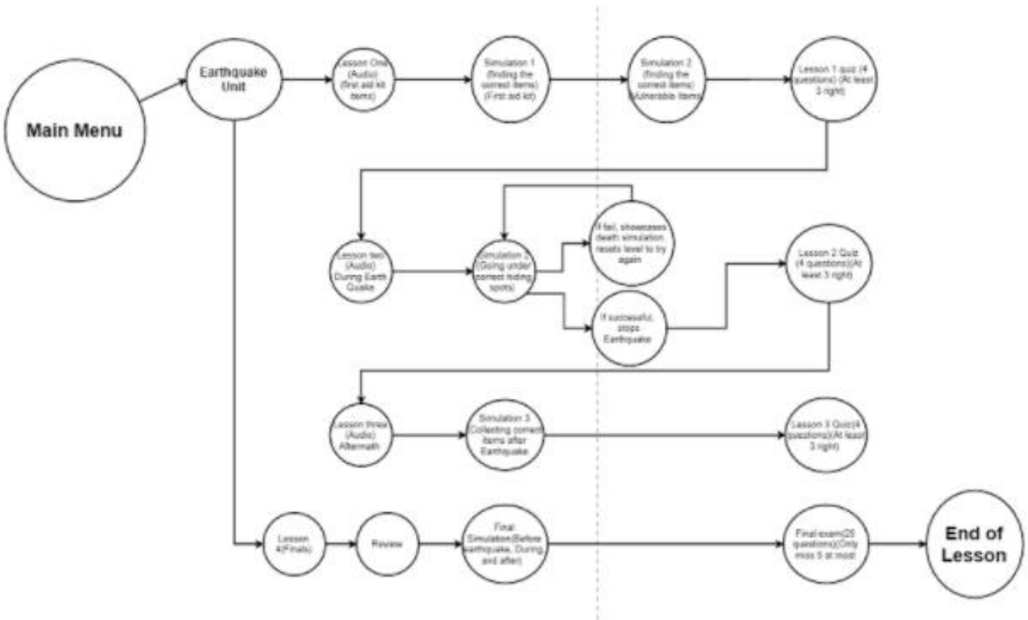

Figure 1: components of the Safety Lifetime system

As a demonstration of the components, we should look to this flow diagram that we have created. Upon the main menu, there will be a button for the learner to select the earthquake unit if you wish to precede. We broke the entire lesson into three smaller lessons: lesson one for earthquake preparation, lesson two for safety during an earthquake, and lesson three for what to do after an earthquake. The lessons must be learned in order, and upon completion, the learner will have the option to take lesson four which is a compilation of all the previous lessons if the learner wants to review the material in a do to prepare for an earthquake. After the video, lesson one of the simulations will run and require the learner to pick up items essential to earthquake preparation. Once the first-person character comes within the sphere collider, the learner can hit P to collect the item. The collection of all six items trigger the next event which will be a six-problem quiz. If the learner gets less than five wrong on the quiz, it will trigger the event for the video of lesson two where the learner will learn about duck-and-cover. The simulation for lesson two will start after the learner finishes the video of lesson two and require the learner to hide in a spot marked by a small green ball under a table for duck-and-cover. We used the Unity animator to rotate the head of the first-person character at various angles to create the earthquake affect, and we used the same script as the previous lesson to trigger the quiz event. Once the first-person character comes within the collider of the green ball, it will automatically collect the ball and thus trigger the next event. We added a few seconds lag to more realistically simulate the earthquake, and the quiz will start in three seconds after initial collection of the green ball. The completion of the quiz will take the learner to the video of lesson three which will cover the safety procedure after an earthquake. Similarly, after the end of the video, the learner will be required to apply their knowledge in a simulation where they have to first contact local authorities and move to a safe clearing out of the house. The completion of the simulation will take the learner to the final quiz. After completion of the final quiz, the lesson will end.

3.2. Implementation

In Safety Lifetime, when a character is moving out of the house, there is an object outside that represents the action of contacting emergency services, and for it to be activated the character needs to be near or at one place with the project, and press key (p) to activate the action. However, it is hard to assign the letter to represent the action of picking up and using the item. The way I solved the problem is using the concept called collider in unity, assigning the player and the sign as colliders. When they collide with each other, it generates an event which would show that the player has activated the action at the item’s spot. Another challenge was I did not know how to create an easier way for the quiz to move onto the next scene after the user answers 5 questions right. There are multiple quizzes, which means I have to write a function multiple time. I solved that problem by creating one function called correct *choice()* which transitions into the next scene when called to run.

```
// PlayerMovement
private void PlayerMovement( float horizontal, float vertical )
{
   bool grounded = controller.isGrounded;
   Vector3 moveDirection = myTransform.forward * vertical;
    moveDirection += myTransform.right * horizontal;
    moveDirection.y = -10f;
    if(jump)
    {
          jump = false;
          moveDirection.y = 25f;
          isPorjectileCube = !isPorjectileCube;
    }
    if (grounded) {
          moveDirection *= 7f;
          controller.Move( moveDirection * Time.fixedDeltaTime );
   }
    if (!prevGrounded && grounded ) {
          moveDirection.y = 0f;
          prevGrounded = grounded;
    }
}
```

The two parameters (horizontal and vertical) represent how hard the user presses the button, vertical and horizontal for the character's movement in the game. W, A, S, D are represented for movement and space for jump. The Boolean value of bool grounded determines if the user-controlled character is on the ground or if the character is in the air. The "myTransform.forward" and the "transform.right" uses the physics equation of the vector function(a value, and a direction) to move the player from the position it is in, which ultimately performs the action using the "controller.Move" function. If the user is jumping, proved by boolean value true or false, the mathematical equation of multiplying the position of y to be a fixed value of 25 by adding 25.If user is grounded, proved again by boolean, the movement is generated to be larger and multiplied speed by 7 (moveDirection *= 7f) to move faster on the ground. There are two logical parameters, prevGrounded and grounded. If prevGrounded and now grounded, it means the user was in the air, and the value for ground movements are added after landing. This is the overall process of movement in one frame of the program.

```
public void correctChoice()
{
  correct += 1;
  if (correct >= 5)
  {
     UnityEngine.SceneManagement.SceneManager.LoadScene(NextScene);
   }
   questionPanels[questionNumber].SetActive(false);
   questionNumber += 1;
   if(questionNumber<questionPanels.Length){
     questionPanels[questionNumber].SetActive(true);
   }
}
```

This abstraction I chose is the program for true or false answers on a quiz. If the user gets one question right, he gets 1 point. Using a loop and creating a function called *"correctChoice()"* made it easier. The program also determines whether the user has picked enough correct answers and achieved a score of at least 5 questions right. As the user passes the score, the next scene and simulation loads, whereas if the user gets less than 5 questions correct, it starts over at question one of the quizzes. It would be complex to have this code in multiple places, since the quiz and questions appear multiple times after each lesson and simulation. Now, if the function is called, it takes care of most of the quiz program and achieves the goal of counting points and transitioning to the next scene.

4. EXPERIMENTS

To verify the effectiveness of our simulation, we performed a small-scale user study in which we selected 20 users of very similar educational backgrounds. Group A is given booklets of earthquake educational materials, while Group B is provided with the game system, Safety Lifetime. Each group was given a 10-minute studying period, and were asked to take a quiz regarding earthquake safety. The contents of the quiz are all covered in the booklets and the simulation, and none of the questions overlap with the questions that were part of the simulation. The Quiz taking environments are the same, and all communications or outside interference have been monitored and deterred. The results were then compared to see if there is a distinguishable difference between the two learning systems.

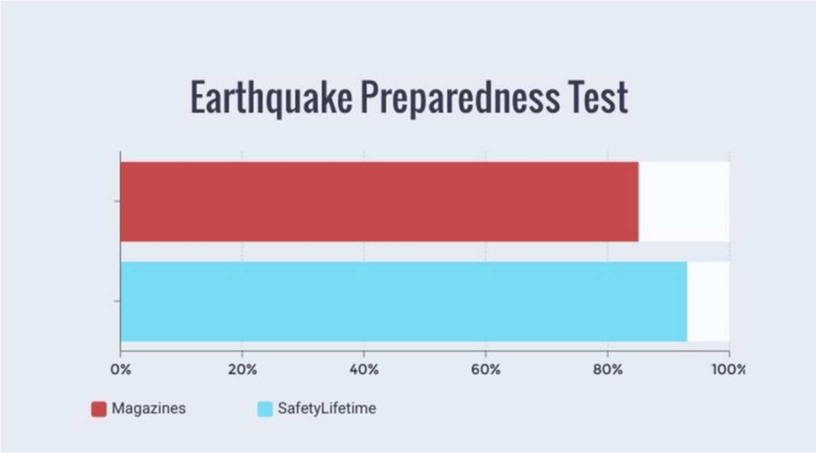

Figure 2: Earthquake Preparedness Test of the Safety Lifetime system

The graph above shows the averaged quiz scores of Group A and B. As can be seen, there is an 8% difference in their quiz scores with the scores from Group B being slightly higher than Group A. Though this experience cannot definitively prove the simulation's effectiveness as slight variations in the subjects' inherent earthquake survival knowledge can have a noticeable impact in a small subject pool, it does seem to suggest a correlation since a 0.8-point score difference is quite significant for a 10-question quiz.

5. RELATED WORK

Dr. Fatimah Lateef explained that the introduction and use of simulation-based learning can be very valuable in replacing and amplifying real experiences in medical education and that "Teamwork training conducted in the simulated environment may also offer an additive benefit to the traditional didactic instruction, enhance performance, and possibly also reduce errors." [8] In this project, we also attempted to utilize simulation-based training to enhance the quality of earthquake survival education. Steadman, Randolph H utilized a randomized control trial to show that full-sale simulation-based learning is more effective than problem-based learning for teaching fourth year medical students regarding acute care assessment and management skills [9]. In this work, we also show similar improvements in the quiz score of learners using our simulation compared to traditional style learning. Cant, Robyn P., and Simon J. Cooper reported in their paper that their review of quantitative evidence for medium to high fidelity simulation using manikins in nursing, in comparison to other educational strategies concluded that simulation based learning is an effective teaching and learning method when best practice guidelines are adhered to and may have advantages over other teaching methods [10]. Though this report examines mostly physical simulations, the advantages of physical simulations are comparable to the digital simulation we utilized in our project.

6. CONCLUSION AND FUTURE WORK

In this project, we created a simulation which we named Safety Lifetime in hopes for finding a more effective method to educate learners on earthquake survival. In order to test the effectiveness of the new training system, we performed a small-scale user study in which we asked two groups of ten users with similar educational backgrounds to study and take a 10-question quiz in a similar and highly controlled environment. Group A was given traditional earthquake survival education material while the other was given the Safety Lifetime simulation. The result shows that the average score of Group A is 8.5/10, while the average score of Group B is 9.3/10. This 0.8 difference is quite significant as this is only a ten-question quiz though it cannot definitely prove the effectiveness of the simulation as a result of the small subject pool which could be affected by the differences between the users' inherent earthquake survival knowledge before the experiment.

In this project, we are limited by time and resources, the graphics of the simulation and the control of the first-person view can be refined with more high-resolution assets from the Unity Asset store. In the simulation itself, we also did not include different branching pathways and different ending within the simulation due to its relative complexity. The simulation's compatibility with IOS platforms can also be optimized. In addition, what was stated in the methodology section was the coding process of Unity where we figured out the variables for each handlers and abstractions. Many algorithms were used with one following another. We also had to use parameters to build a scene and objects in the simulation. By linking each scene from algorithms and displays altogether, the program is created to run through a series of events.

The simulation is just a prototype. Our goal is to expand our prototype to present information regarding other natural disaster and accident preparation for the learners in a more effective and entertaining way to educate them about their personal safety.

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