

Treme-treme - A serious game to teach children earthquake preparedness

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ABSTRACT

Earthquakes are known as one of the most dangerous natural hazards due to their unpredictability, and because it is not possible to know when a major seismic activity will occur, it is highly recommended to be prepared. Due to the growing interest in Serious games unique characteristics to teach and train individuals, there was an opportunity of using these games to better prepare and inform people about earthquakes. This work describes a Serious game that was developed to teach elementary school children about common practices and procedures to take before, during and after an earthquake as well as warn them about the risks and promote discussion among the students and diffuse this knowledge to their families. To achieve this, we investigated the characteristics of Serious games and studied games with similar purposes in order to create a game able to entertain while teaching pedagogical content. Through the results obtained from the tests conducted we can conclude that our game was able to successfully achieve its purpose, being able to raise awareness about earthquake preparedness in schools.

keywords : Serious game, Earthquake, Preparedness, Children

INTRODUCTION

Since the dawn of times, earthquakes are one of the most dangerous and catastrophic events that have been taking lives and leaving trails of destruction all over the world. Besides their destructive power, the main reason of why they are so dangerous relies on its unpredictable nature and in the fact that many people are not prepared or trained to take a quick response to it.

Children are one of the most vulnerable groups in our society: They are not independent, they have a narrow capability to evaluate danger, and are not usually well informed and trained about common behaviors and earthquake consequences.

This work presents *Treme-treme*, a Serious game developed to teach fourth grade children the importance of earthquake preparedness and the risks of a major seismic activity. In this game players learn how to build an emergency kit, where the safe and dangerous places are, and what to do before, during and after an earthquake.

Treme-treme was developed in partnership with The Department of Civil Engineering of Instituto Superior Técnico under the European project UPStrat-MAFA ("Urban disaster Prevention Strategies using MACroseismic Fields and FAult Sources), which helped us understanding the context from the children point of view and contributed with useful knowledge, requirements and objectives that came to be turned into game play elements.

EARTHQUAKE PREPAREDNESS

Science has been trying to predict earthquake occurrences diagnosing its precursors from the principles of location, date and magnitude with no success. Because of that and to minimize the damages, is imperative to be prepared. Fulfilment of some very simple standard rules before, during and after an earthquake can be a definitive factor to reduce injuries or even improve odds of survival.

With the help of Department of Civil Engineering of Instituto Superior Técnico and with the information online available by American Red Cross, Ready and Instituto português do mar e da atmosfera (IPMA), three organizations whose part of the vision is to help and prepare people for disasters, we were able to collect the most common procedures to take before, during and after an earthquake:

What to do before

It is crucial that everyone knows what to do when an earthquake strikes. Any member of the family aware of earthquakes danger and the most common procedures to take when facing it, should gather all family members and share that knowledge with them.

Everyone should know instinctively which places are dangerous and which ones are safe. The safest places usually are, corners of supporting walls and under tables and beds, while the dangerous ones are those close to objects that might fall, break or splinter, like windows mirrors, ceiling lamps and high-shelves.

Everyone must be aware that a seismic activity can occur at anytime, anywhere, during the day, at night, in home, in other people houses, at work, street, public transport, driving, in a mall, cinema, among others.

Together, everyone in the family must talk about an emergency plan and about a meeting place. During and after an earthquake people can get lost or some family members are separated at that moment, moreover after an earthquake individuals should leave the building, because even if it seems safe an aftershock can strike at any time putting its stability in risk. It is important that everyone remembers that communication devices might not work due to line congestion or damaged infrastructures, and the line must be free for life or death situation. Text messages should be used instead. Either way families should arrange a contact from a person outside of the region where they live to coordinate all the information of the elements of the family in case they were dispersed before the event or are directly unreachable.

All the family must be encouraged to build an emergency kit together, so that everyone knows how to do it and which objects are essential to survive. Following a disaster, having extra stock at home or supplies can help families to endure evacuation or home confinement for several days. An emergency kit should consist in an easy-to-carry backpack or duffel bag preferentially near the exit door or convenient stored in a place known and reachable by all family members, with items for at last 3 day long duration. Some of the emergency kit basics are:

- A portable, battery-powered radio or television and extra batteries;
- Flashlight and extra batteries;
- Bottled water (1 liter / person / day, minimum);
- A whistle;
- Canned food for 3 days by person;
- First aid kit and first aid manual;
- Supply of prescribed medications;
- Emergency contacts including police, fire, nearest hospital, and family;
- One complete change of clothing and footwear for each family member, sturdy shoes or work boots, raingear, hat and gloves, underwear;
- Blankets or sleeping bag for each family member;
- Sanitation and hygiene items such as toilet paper, soap, hand sanitizer, liquid detergent, disinfectant, feminine supplies, shampoo, deodorant, toothpaste, toothbrushes, comb and brush and medium-sized plastic bucket;
- Kitchen accessories such as a can opener; paper cups, plates, and plastic/disposable utensils, utility knife, sugar, salt, matches in a waterproof container and a portable stove;
- Credit card and cash, personal identification and important documents, or at least copy thereof.

Should be taken special attention to the needs of very young, older and disabled family members, babies usually need formula, diapers, bottles, powdered milk and medications, while some adults need their heart and high

blood pressure medication, insulin, prescription drugs, denture needs, contact lenses, extra eyeglasses, hearing aid batteries, and other physical needs. Families should remember to keep their kits working, changing the food and water every six months to ensure their freshness, and replacing batteries, clothes and other objects as necessary because family needs change over time.

People should know where emergency exits are, and keys must be placed close to the respective doors, for easy access. Next to the phone and in the mobile phone, must be kept an updated list of emergency contacts including police, fire, nearest hospital, etc. It is recommended to always keep a handy and operating flashlight, especially near the bed, because earthquakes can strike at any time. Operational extinguishers should be placed near places where there is high risk of fire, for a more fast and handy response.

What to do during

During an earthquake some people get apathetic, paralyzed by fear waiting for instructions or doing unreasonable actions that potentially put themselves and those nearby in danger. For this reason is very important to create simulated environments to train problem solving under high pressure situations and teach correct behaviors to take during a real occurrence.

What to do during an earthquake highly depends of where the person is:

If Indoors

In home or inside of a building, resident's behavior relies on how high in the building they are. If they are in a high floor, they must stay there, protect themselves in a safe place, avoid falling objects, and not rushing to elevators or stairs. Otherwise if in the lowest floor or if having enough time to go outside to a safe open space, it is preferable than stay inside the building. This situation is mostly applied when people know in advance that an earthquake is coming, a reality that is not applied in all countries or all situations, for this reason we list some of the most useful behaviors to take when the earth shakes and people are inside a building:

- Individuals should drop to the ground; take cover by getting under a safe place like a table, bed or desk; and hold on until the shaking stops. If there is any safe place close, individuals should cover their faces and heads with their arms and crouch in an inside corner of the building. Because the smaller the area the less likely it is to be hit by falling objects. People should move as little as possible, only a few steps to a nearby safe place. Most injured persons and fatalities in earthquakes occur to people trying to leave the building during an earthquake, by falling objects, debris and collapsing walls;
- Doorways should not be used except if they are strongly supported and close by, because many

inside doorways are lightly constructed and do not offer protection, and the door movement during the shaking can cause great harm;

- Individuals that are in bed when the earthquake strikes should stay there, curl up, hold on and protect their heads with a pillow, unless there is a heavy light fixture over them. In that case they should move to the nearest safe place;
- People must face away from glass, windows, outside doors and walls, and any objects that could fall or break, such as lighting fixtures or furniture, and be aware that the electricity may go out or that electronic devices might not work as were supposed making sprinkler systems or fire alarms turning on even if there is no fire;
- During the shaking, people should not try to leave the building. Debris can fall over individuals at any time and exits, stairs and doors are places that get wrecked easily, or might be obstructed with people trying to leave the building. For these reasons, people must remain protected inside the building until the shaking stops and it is safe to go outside.

If Outdoors

Individual's reaction depends on their geographic location at the moment. If in an outdoor open space, individuals should stay calm and remain there, while in a mountainous area or near unstable slopes or cliffs, because landslides are often triggered by earthquakes, they must be alert for falling rocks and other debris. If close to the sea or rivers, people should move away to high places, because it is possible for the water to break or lap up its boundaries getting into sidewalks, roads or even drag buildings after an earthquake. If close to buildings it has to be taken special attention to the olden and isolated ones and move quickly away from them to prevent injury from falling debris. It is not recommended running or hanging around in streets, because walls, chimneys, balconies, trees, streetlights, power lines, and other objects might collapse.

What to do after

After an earthquake, the disaster may continue. Potential aftershocks, landslides or even tsunamis are expected to occur, in the first hours, days, weeks, or even months after the event, so it is crucial for everyone to be attentive and prepared all the time. After the event, individuals must look around to make sure if it is safe to move, check themselves for injuries and if necessary getting first aid.

People must stay indoors and remain calm until the shaking stops, most injuries happen when people move recklessly during an earthquake. After the shaking has stopped, people must stay calm and alert, counting on future aftershocks and pay attention to overall building condition specially to the walls, electrical wires, gas, ceiling lamps and other objects that might fall over them as well as stairs and floors, and

then if they are sure it's safe to exit, they should do it as soon as possible, an aftershock can strike any time or the building might not hold much longer.

Elevators must never be used, aftershocks, power outages or damages might let it stuck, stairs must be used instead after evaluating its conditions.

Matches and lighters should never be used, a gas leak can happen and the flame might cause an explosion. We should turn on and listen to a portable, battery-operated radio (or television) for updated emergency information and instructions. If the electricity is out, this may be our main source of information. Local radio and local officials provide the most appropriate advice for each particular situation. People must avoid going through places with loose electrical wires, and must use a cellphone just in very urgent situations like highly injured, gas leak or fire.

Preparedness in school

Serious games in education have yet been seen as an auxiliary tool for teachers. Because of that we must understand the way teachers instruct earthquake topics as well as the way they see video games as learning tools [4].

One issue that needs some consideration is that most teachers are not qualified to teach about earthquakes and the proper behavior to take in such situation. They usually, don't follow any standard guideline, instead they use their own creative ways of teaching based on books or previous experiences. The teaching of this topic relies many times on their personal interest and creativity to motivate students. This means that having enthusiastic teachers is a very important factor when thinking in creating enthusiastic students capable of retaining and spreading the topic [4].

The unpredictable and unavoidable nature of earthquakes, make its preparedness among children highly important. They are undoubtedly one of the most vulnerable groups of society and the future assets of our community, being their protection considered extremely important. This way is very important that they know what to do by themselves. Educating children about natural hazard risks and the common procedures to take in each situation can be considered as an effective strategy to broadcast safety procedures to the entire community. In other words using enthusiastic motivated children is an effective way to inform most of the population about these issues [4].

Children in school are usually excited to participate in drills, being believed to be one of the most favorite activities among children [1, 4]. Simulated drills objectives are, letting children be familiarized with different preparedness procedures, evacuation, simulate drop, cover and hold, and identify the most safe and dangerous places, awareness of emergency exit doors and connection ways.

This drills requires many times that normal lecturing stops, and an event to be created by the school, being spent time and sometimes qualified people for this occasion. Serious games would bring many advantages for this situation; players could have a more vivid experience through a game that is not possible to recreate in real world, because of its cost, technology and safety issues. These games would fulfil the lack of awareness about common practices and procedures in real world situations, improve problem solving under pressure that could be expected in a realistic environment, putting the player in a situation with lack and incomplete information, in a dynamic, complex and nondeterministic environment that change over time, with limited time just like in real situations [5].

IMPLEMENTATION

Treme-treme is a 2D game designed to teach the basics of earthquake preparedness to elementary school students, placing them into a virtual environment where they have a vivid experience that can't be other way currently achieved.

It is most likely that the game came to be used into a classroom environment or at home as a homework assignment, and with this in mind we start designing the game aiming these two realities. Our solution was publish the game to web and let students and teaches play the game from their browsers. This has many advantages for teachers that do not have to instant the game in each computer and for children that might not know how to install a game.

To make the interaction easy to children understand, every action in the game is performed using a mouse no navigate in the environment and the left button to Interact with its elements.

In this Serious game, the player has to face in single player several challenges in two distinct levels: In the first one the learner has to build an emergency kit. The level starts with non-scrolling top view of a table with an empty emergency kit and a group of objects and the player must build an emergency kit by choosing which of them are the most important when facing an earthquake and place them into the kit. The second level teaches children how to behave before, during and affecter an earthquake. This level is a sidescrolling world, where the learner has to face an earthquake indoors. At the beginning of the level, he is alone in his home while suddenly he hears an earthquake coming and the earth shaking a little. To protect himself from the outcome damage that the earthquake might cause, the player has to find a safe place before the strike. During the seismic occurrence the player has to stay calm and wait for the shaking to stops. After the event the player faces another challenge, a gas leak and dangerous electric wires, he has to turn them off so he can leave the house before the aftershocks and move to his family meeting place.

Build an emergency kit



Figure 1. Treme-treme's first level

Building the emergency kit is the first *Treme-treme's* level. In this level (Figure 1) the player has a 2D top view of a table with an empty emergency kit and a group of objects. To be succeeded in this level, the player must choose the most important objects to have in the kit and put them on it. To do that he just has to use the mouse and left click and drag each one, and drop it inside the kit. There is no time limit and the player can try as many times as necessary until doing it right and then moving to the next level.

In order to make the game simple and to not overwhelm the children with too much new information we restricted the number of objects to carry on the kit by six fundamental items easy to memorize and good enough to motivate and to get the main idea of building one.

This level has nine objects but just six slots inside the kit to be filled. The player has to choose which six of the nine objects should be put into the kit while the remaining three are not as useful as the others.

The main idea is to make the children think about which objects are really needed after an earthquake.

The correct objects are: a portable radio, batteries, flashlight, canned food, water bottle and a whistle, letting behind the wrong ones: a teddy bear, an handheld game console and a book.

If the player has put one object inside the kit and for some reason wants to take it out, he can easily do that by dragging and dropping the respective object outside the kit or by dragging and dropping an object over the other. In that case they will switch positions and the object previously in that position will move to the original position of the object that has been dropped.

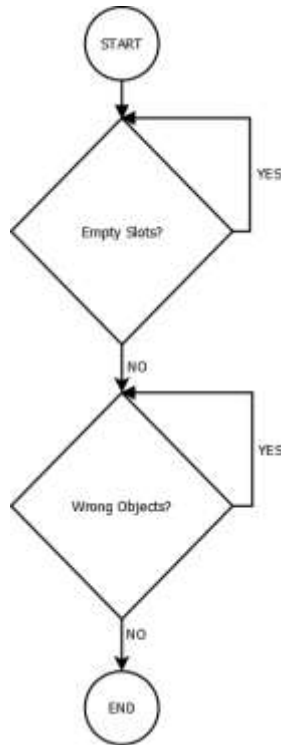


Figure 2. Structure of the first level. The player can just move on when in the emergency kit there are no empty slots and all the objects are useful for surviving an earthquake.

This level, displays information in four distinct situations: At the beginning of the level information is displayed to inform what to do. After clicking in the ok button, if for some reason, the player has one or more wrong objects inside the kit or if some fundamental items are missing the game displays information in order to put the player on the right track. When the player has the kit with all the correct elements on it, after clicking in the ok button this level ends and the player moves to the next one.

Facing an earthquake



Figure 3. Treme-treme's second level. The player chose a girl and to leave the house he has to turn the gas off.

Treme-treme's second level (Figure 3) is a 2D side scrolling game, played in single player, where the player has to face an earthquake while indoors. To simulate the context of a real major earthquake under familiar circumstances, the game places the player in a house where he has to perform the best practices in each one of the three earthquake preparedness phases: before, during and after a major seismic event. Each phase has a different challenge that must be overcome to proceed to the next one and if the player dies, he has to start the level again. The main focus of this level is to teach children where the safe and dangerous places are and how to behave in each situation. In this level the player has to calm down evaluate the surroundings, think fast under pressure and make the right decisions.

Next, we describe the three different phases, its challenges and how to overcome them:

Before

Before the earthquake the player is randomly placed somewhere in a high floor of a house, he starts listening an earthquake far away from his location and observes the house shaking slightly. He must protect himself to overpass this phase and to do that he has 10 seconds to process the information of where he is, what is happening and where to go, make a decision and act accordingly. In this phase is expected that he gets protected under a bad or a resistant table, otherwise as a punishment for doing a wrong behavior, if after that initial time the player is not protected and is close to dangerous objects, they will fall or break, killing him. In other way, if there are no dangerous objects nearby and if he is unprotected, part of the ceiling collapse over him leading to the same result. Every time the player gets killed he has to do the level again until his behavior becomes correct. To control the character the player has just to use the mouse and left click wherever he wants him to go: if he wants to change floor he has just to click on the other floor, if he wants to protect under a bad of table he has just to click in those objects.

During

When the earthquake strikes, the player must stay protected under a bed or a resistant table and calmly wait for the shaking's end, otherwise if not protected or if he rushes to the exit the same punishments mentioned before are applied here.

After

After the shaking has stopped, an aftershock can strike at any time so the player must leave the house as soon as possible. In this phase a gas leak happens and some electrical wires get loose and if the player gets close to any

of those two he dies. To avoid such situation he must get close to a valve and click in it to turn off the gas and do the same to the switch in order to make the loosed cables harmless. After facing these obstacles the player must leave the house and move to his family meeting place. Because it wasn't convenient to the player facing an aftershock with time intervals based on real world events and to reduce the boredom we set-up the aftershock occurrence as a random value between 10 and 20 seconds, so the player could have the outcome of the experience without much waiting. The after phase must be done in at last two aftershocks otherwise the house will collapse and the player will die.

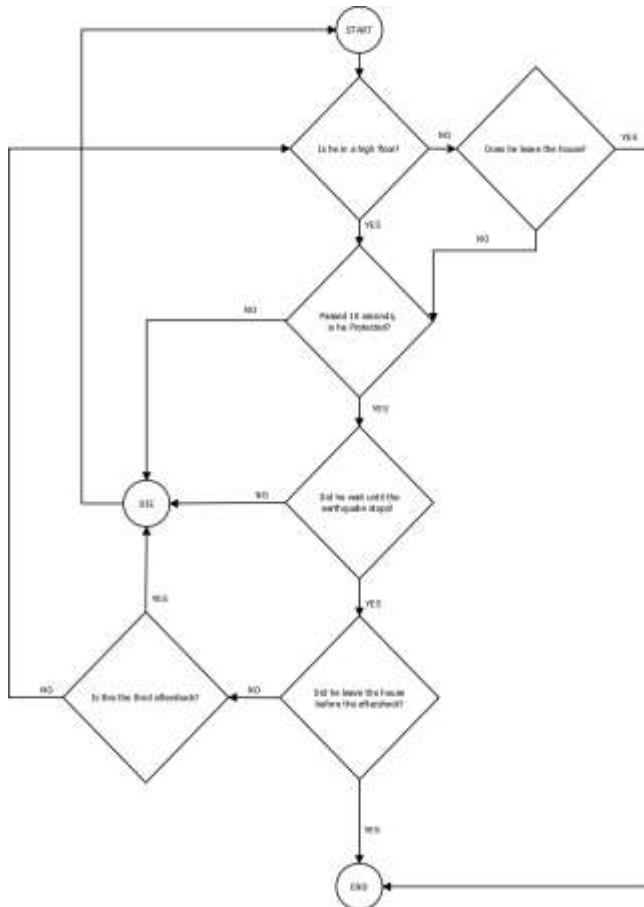


Figure 4. Overall compact structure of the second level

In this level, most objects as can be seen in Table 1 have a behavior that is triggered randomly, when the player gets too close or by interaction. All the objects that might kill the player have the behavior of falling, breaking, intoxicate or electrocute him during or after a seismic occurrence.

Most objects have a chance to break or fall during the earthquake, however if the player is too close to them the chance becomes 100%, the behavior is triggered and the object falls or breaks and if he is not protected, he dies.

Objects	Behavior	When
Ceiling rocks	Fall	During
Shelves	Fall	During
Ceiling lamps	Fall	During
Frames	Fall	During
Balcony	Fall	During/After
Windows	Break	During
Mirror	Fall/Break	During
Objects hanged on wall	Fall	During
Gas valve	Turn off	After
Gas leak	Intoxicate	After
Electrical switches	Turn off	After
Electrical wires	Electrocute	After
Bed	Protect	Before/During
Table	Protect	Before/During

Table 1. Objects in the second level, their Behavior and when they can be triggered.

The gas valve and the electrical switch are two objects that when interacting with them, they turn off the respective obstacles: the gas leak and the loose electrical wires. In addition, the bed and the tables are other example of interactive objects. The player click to where he wants to send the character, if he clicks on the bad or in a table the character move to there and perform accordingly.

While the player controls the character, the game camera is focused in following the player, however once protected during the seismic event the player can't do much and has just to stay protected waiting for the ceasing of the shake. For this reason, take advantage of the situation and in order to improve the overall understating of earthquake risks and consequences the camera zooms out and became focused in the house instead in the player showing the overall house condition and the dangerous behavior of objects inside. After the earthquake the zoom comes back to normal and the camera becomes again focuses in following the player.

Technologies

The game was developed using Unity3D a well-established and reliable game engine that allowed us developing this game with high level programming, grant us free distribution and multiplatform porting. For scripting, the Unity framework allowed us the usage of C# and JavaScript, while for texturing all the work was done using Photoshop CS5.

One of the main reasons why we selected this engine apart from what was mentioned before was the community. The forum support grant developers fast response to common issues while continuously building the game and the examples available help programmers developing their prototypes faster than ever before.

EVALUATION

Evaluation Methodology

The objectives of the tests were:

- Verify if players understand earthquake preparedness awareness matters;
- Check if the game makes people broadcasted the information to their family and friends.

Preliminary tests

Before the final and official evaluation we decided to do a preliminary test to get a first impression on *Treme-treme*'s overall performance, mostly take a look into the gameplay difficulty, interface design and observe players reactions during the gameplay session.

The first tests were made with a class of third grade students with disciplinary and learning problems. Most of them were unable of proper reading what led to a situation where they were unable to know what to do or where to go. The tests were done in their school in a room reserved for the occasion, and because there were just two computers available to run the tests, just two students could do it at time, what lead to a situation where just 14 from 28 students could do the test. Even so, with this first contact we were able to gather valuable information to improve player's overall learning experience through *Treme-treme*.

Evaluating Treme-treme

First Survey

Question 1 - Are you a boy or a girl?

Possible answers: Boy, Girl

Question 2 - Are you used to playing video games?

Possible answers: Yes, No

Question 3 - If your answered yes in the previous question, in which device do you use to play?

Possible answers: Tablet or cellphone, consoles, computer

Question 4 - When an earthquake strikes, which are the SAFEST places in your home?

Possible answers: Balcony, under a table, close to a shelf, close to a window, in stairs, under a bed, in the bathroom.

Question 5 - When an earthquake strikes, which are the MOST DANGEROUS places in your home?

Possible answers: Balcony, under a table, close to a shelf, close to a window, in stairs, under a bed, in the bathroom.

Second Survey

Question 1 - What do you think about the game controls?

Possible answers: Easy, more or less, could be easier, hard

Question 2 - For you the informative text was:

Possible answers: Useful, I read it but was boring, I have just read some of them, I did not need to read

Question 3 - For you how much difficult was the game?

Possible answers: Easy, more or less, could be easier, hard

Question 4 - Which objects would you like to have in your emergency kit?

Possible answers: Bottled water, Canned food, Whistle, Flashlight, Extra batteries, Portable radio, Teddy bear, Portable video game console and Book

Question 5 - When an earthquake strikes, which are the SAFEST places in your home?

Possible answers: Balcony, under a table, close to a shelf, close to a window, in stairs, under a bed, in the bathroom.

Question 6 - When an earthquake strikes, which are the MOST DANGEROUS places in your home?

Possible answers: Balcony, under a table, close to a shelf, close to a window, in stairs, under a bed, in the bathroom.

Question 7 - Did you finish the game?

Possible answers: Yes, No

Question 9 - For you, which are the most important things to do when an earthquake happens?

Possible answers: (Open question)

Question 10 - Would you talk about earthquakes to someone? If yes to whom?

Possible answers: (Open question)

RESULTS

The overall evaluation was done with 94 students, 14 in the preliminary test and 80 in the second. Because the first group of student could not read, and understand some basic questions we had to adapt the questions and ask differently of what was initially prepared. This lead to a situation where is hard to compare and merge the performance of this two very different tests. For this reason, and because we have a significant number of samples in the second test we are going to present the results from that test while the first one served as a test to improve the game's overall experience and solve some problems. Unfortunately, we were unable to take any photos, filming or recording the

audio of the experience, to do that would be needed parents authorization of all students, and would not bring much benefit.

Next, we describe our results and if our goals were met through this game:

Goal 1 - The player must know how to build a simple emergency kit and which objects are the most important for his survival

Because we were afraid that asking about kit objects before the test would affect players performance during the gameplay session we decided to make the questions just after it and use the answers and the information retrieved from our database, related with level completion and number of times that they fail trying doing it, to verify if the players learned how to build an emergency kit.

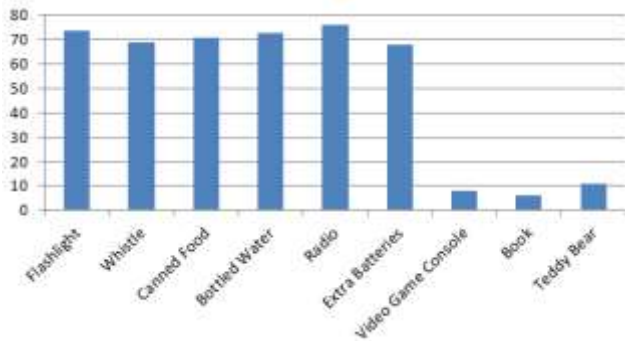


Figure 5. This graphic displays each object available in level 1 and how many people choose each on as the one that would consider most useful. Base in observation we can conclude that not all participants choose six elements and a significant number of "wrong" objects were selected.

Through observation we found that building the emergency kit caused much discussion among most participants. They seem not understand why could not bring some objects like a Teddy bear to help them sleep at night or other entertaining object.

Number of tries	Percentage
3 or more	35%
2	45%
1	15%
0	5 %

Table 2. This table shows the percentage of tries building the kit.

The Table 1 shows the number of tries that the players did to overcome the level. Evaluating the data we can easily

conclude that before playing the game most students did not know how to build a basic emergency kit (80% failed 2 or more times). Based on this, observing the Figure 5 and because 100% of students were able to successfully complete the level, we can conclude that after playing the game most students became more aware about which objects must be on an emergency kit.

Goal 2 - The player should know where the dangerous and safe places are and what to do in each situation

Figures 6 and 7 present the percentage of participant's understanding about dangerous and safe places before and after taking the test.

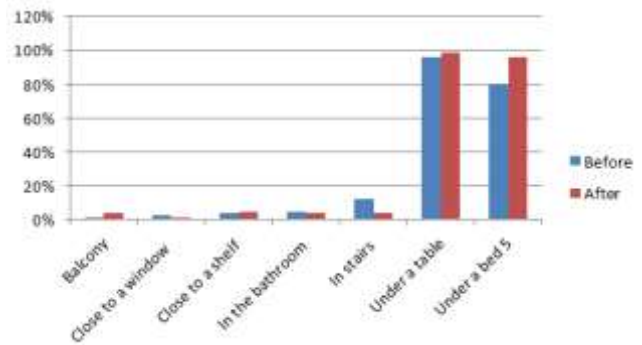


Figure 6. Which places participants think be safe - Comparison between before and after doing the test.

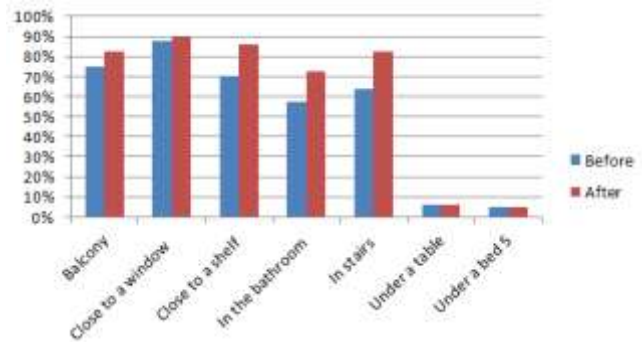


Figure 7. Which places participants think be dangerous - Comparison between before and after doing the test.

The good results before the gameplay session shows that the participants had some prior knowledge about dangerous and safe places during an earthquake. However, comparing the values before the gameplay session with the results obtained after it became clear that playing the game change positively their previous knowledge even when there were some previous understanding about this topic. We can conclude which this test that even with some prior knowledge about earthquake preparedness that can be enhanced and refined through Serious games.

Goal 3 and 4 - The players should learn that after a major seismic activity it is important to leave the house but they must turn off gas valves and electrical switches before doing it and move to his family emergency meeting place

From the all sample of participants 92.50% finished the game, and to do that they had to leave the house and find their families meeting place. To achieve such thing they had to turn off the gas valves and electrical switches before too much aftershocks collapsed the house. Evaluating the question 9 from the second survey we conclude that most participants understood the risk and what is needed to do before leave the house. Further looking into the answers we can see that most players could even link what was happening in the game to a real world event.

Gameplay

Game controls where considered mostly not too difficult but not too easy to master with 47.50%. 26.25% of students voted as easy controls and 16.25% as could be easier. 10% of the students considered the controls difficult. With this results we can conclude that even if accessible for must plays, 26.25% shown some difficulty learning how to control the character and interact with world.

After analyzing the surveys data we observe that 71,25% of the participants considered *Treme-treme* or easy or with just the right difficulty, what we consider good results. However 23,75% have yet consider for some reason the game difficult.

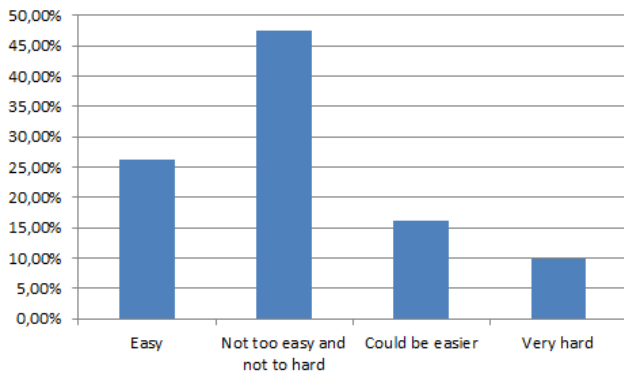


Figure 8. Percentage of how easy the controls were considered

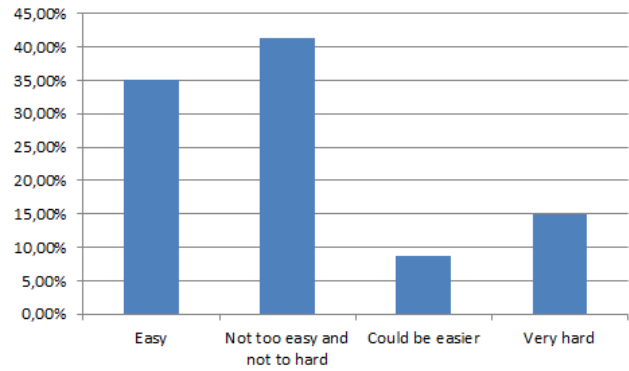


Figure 9. Game difficulty percentage of votes

Through observation we found out that some participants answers might not correspond to the truth. We saw cases were the player died many times but considered the game easy. Despite this, we have to consider these values as true and consider in future better ways to avoid this situation.

Because in the preliminary tests participants could not read we made adjustments to make the messages take longer and we re-right them differently to be more understandable of what to do. Moreover, we added extra information before each level to inform how to control the character and how to interact with objects.

Because of this changes we decided to ask about to verify if the changes were effective. After analyze the surveys data we conclude that the information displayed was undoubtedly considered useful with 92.5% of the votes, this means that participants found that read the information displayed had consequences on their performance which means that well prepared players would have an improved performance during the game, and better odds of successfully overcome the game obstacles.

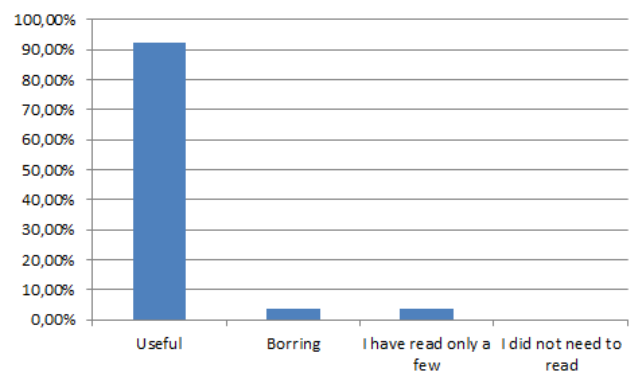


Figure 10. Percentage of how useful was the overall information displayed in the game

Base on the results on questions 9 and 10 we can say that *Treme-treme* contributed not just to the overall understanding of this topic but to move the experience beyond the game play session making players broadcasted the experience. After reading the answers we concluded

that this Serious game can serve as a tool to teach children and motivate them to spread this topic to their families and close friend.

We observed some cases, mostly in the preliminary tests and some in the final test, where the player had some difficult understanding the controls and in the survey they considered them easy. The same children wanted to play again and try new ways of facing the earthquake. Unfortunately we had very limited time to each test and that was not possible. In future, schools could apply this game to teach earthquake to their students in a classroom environment and let them reinforce that knowledge playing again in home as a homework assignment. From the students that took part in this test, 92.50% finished the game what means that most of them were able to successfully go through the phases: Before, during and after, understanding each situation and acting accordingly.

In conclusion the game was successfully able of teaching early aged students about the most common practices to be taken before during and after an earthquake. More than making them understand the new material, the results shown that the game was capable of making them revise their believes, refining their previous understanding in this matter.

CONCLUSION

Treme-treme is a game developed with the objective of alert children to the risks of a seismic activity and teach them very simple practices than can make the difference when facing the real event. The Serious game succeeded teaching students earthquake preparedness in a classroom environment. After the game play session players are able to better understand how to build and emergency kit, were the safest and most dangerous places are and what to do before, during and after the seismic occurrence. The game reveled effective even to people with some previous knowledge in this matter and even to students one year older than the initially intended.

In future improvements, the game should be more accessible to those children with reading problems, the controls made easier and the player should learn how to use each object in the kit.

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