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

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Resumo

Os terramotos são conhecidos como um dos maiores desastres naturais devido a sua imprevisibilidade, e como não é possível de saber quando uma grande actividade sísmica irá ocorrer, é altamente recomendado estar preparado. Devido ao crescimento do interesse sobre as características de ensinar dos jogos sérios, houve a oportunidade de usar os jogos sérios como ferramenta de ensino para preparar as pessoas caso aconteça um terramoto. Este trabalho fala sobre um jogo serio que foi desenvolvido para ensinar crianças do ensino primário sobre as normas e condutas corretas a tomar-se antes durante e depois de um terramoto, assim como, avisar sobre os riscos e tentar promover o diálogo familiar sobre este assunto. Para realizar isto, nós investigamos as características dos jogos sérios e estudamos jogos com propósitos semelhantes de modo a criar um jogo capaz de entreter a criança enquanto ela aprende conteúdo pedagógico. Com os resultados obtidos pelos testes feitos, nós podemos concluir que o nosso jogo foi capaz de atingir o seu propósito, sendo capaz de de aumentar o conhecimento sobre terramotos nas escolas.

Palavras-chave: Jogos Sérios, Terramotos, Preparação, Crianças
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 Serious 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 it's purpose, being able to rise awareness about earthquake preparedness in schools.

Keywords: Serious game, Earthquake, Preparedness, Children
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Chapter 1

Introduction

1.1 Motivation

Video games have been gaining more and more acceptance by every one around the world, and according to Gartner, Inc \(^1\), is expected that worldwide video game marketplace reaches $101,615 billion dollars in 2014 and $111,057 billion dollars by 2015 driven by strong mobile gaming and video game console and software sales. According to Michael D. Gallagher, president and CEO of Entertainment Software Association, “No other sector has experienced the same explosive growth as the computer and video game industry”.

Serious games which are defined later in this document, have been documented as a promising educational tool with motivational perspectives, used to teach new matters and reinforce knowledge already learned [Chalmers and Debattista, 2009]. Their applications have been already proved in several areas, expanding the horizons of the “traditional” games, including scientific simulations, industrial and military training, medical and health, education and therapy, advertising, geographic, cultural, social, policy change and awareness among others [Maria Saridaki, 2011].

Studies about serious games and their applications are relatively new, however researchers all over the world are pointing video games as an innovative and powerful tool for learning, due to their unique characteristics. Compared to traditional teaching, learning through games have several advantages - While playing, the player is emerged in a world where is exposed to the pedagogical material and get instantaneous feedback of players actions, has personalized content that let them reflect different situations, and he has many ways to solve problems [F.L. Greitzer and Huston, 2007]. Conor Linehan [2009] said “Embedding the learning outcome within the game mechanics can provide a superior tool for education”.

Nowadays research and development of educational games focused in natural disasters as a theme are still limited [Yi-Shiuan Chou, 2012]. However, With the rising usage of Serious games and virtual

\(^1\) [http://www.gartner.com/newsroom/id/2614915]
simulations and the current computing power available to us, a number of these games have been de-
veloped for personal earthquake safety awareness and evacuation procedure [Aaron DeChamplain, 2012].

The Department of Civil Engineering of Instituto Superior Técnico (DCE) under the European project
UPStrat-MAFA (Urban disaster Prevention Strategies using MAcroseismic Fields and FAult Sources),
has a project about seismic preparedness, and with that an opportunity to create a video game whose
purpose was to teach children about earthquake dangers and the common procedures to take in such
catastrophic conditions. This gave us an opportunity to test the reliability of Serious games as learning
tools for seismic preparedness.

1.2 Context

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. An earthquake is a shaking on the
ground caused by the sudden breaking and movement of large sections of the earth's rocky outermost
crust. This event has the power to alter the surface of the Earth, thrusting up cliffs and opening great
cracks in the ground, causing enormous damage to human lives, collapsing man-made structures and
many times leading to tsunamis, avalanches or volcanic eruptions. One of the main reasons why they
are so dangerous, besides their destructive power, relies on its unpredictable nature, because many
people are not prepared or trained to respond to such situation. For this reason, it is highly important
for everyone be prepared and used to common practices and procedures in order to get better odds of
survival and to improve the safety of their goods.

Because of its destructive and unpredictable nature, surviving a major earthquake depends on know-
ing what to do before, during and after the shaking starts. Because of that, all the family members
should be informed about earthquakes and its consequences, adopt simple preventive measures, know
the safest places and the ones to avoid, plan a meeting place outside the building, know how to build
and conserve an emergency kit, its location, and be prepared in case this event occurs during any time
and any where.

Children are probably one of the most sensible groups in our society. For this reason is highly impor-
tant that they respond independently, correctly and instinctively to a seismic activity, because during the
seismic occurrence, they can be far from their parents or even alone by themselves. Moreover, different
individuals react differently in such event, some become frozen by fear while orders react irrationally,
putting not just their lives in danger but the life of others. For this reason, and to avoid such situations is
highly important having knowledge and training about this matter, to minimize reaction time and improve
decision making under situations of high pressure.

The Department of Civil Engineering of Instituto Superior Técnico (DCE) wanted to create a game
able to inform children about earthquake dangers and teach the correct behaviour to take before, during
and after a seismic occurrence. The game is aiming at eight years old children, so the game must cover
complex information in a simple manner for them to understand. For this reason, they came up with the following messages that they want to transmit with this game:

- The game must teach the player the importance of making an emergency kit, its fundamental objects, having it at home, and take it with us;
- The player should know what the dangerous and safe places are and what to do in each situation;
- The players must be aware that they must turn off gas valves and electrical switches before leaving home;
- The game has to show that it is important to leave home after an earthquake to his family emergency meeting point far away from buildings;
- The game must display how dangerous earthquakes can be, and how much time a person takes to protect himself.

The overall goal with the game is to provide a useful way to help early age students to gain knowledge and preparedness awareness in case of seismic occurrence, develop life-skills and positive safe habits, and diffuse that experience and information to their families and friends.

### 1.3 Objective

This dissertation ambition is to study Serious Games, the importance of its characteristics and their application in emergency response situation, in order to apply those characteristics as design techniques to create *Treme-treme* - A video game whose purpose is to inform early aged children about common practices and procedures, and promote discussion among students in class and diffuse knowledge to their families. After playing the game is expected that players stay aware of the objectives previously presented provided by DCE.

### 1.4 Document Organization

This Document is divided in 5 chapters with the first one presenting the motivation of this work as well its context and objective. The second chapter gives a better understanding of this dissertation subject, being subdivided in three major categories: Serious games, Earthquake Preparedness and Previous games analysis where games with the same purpose are evaluated. After the related work in Chapter 3, we first give an overview of *Treme-treme* and then we describe, in detail its implementation. After that we present a contextualization of level to be implemented in the future. In Chapter 4 we present the tests conducted and the analysis of the results, in order to evaluate our implementation and to verify if *Treme-treme* was able to meet DCE objectives. Finally, in Chapter 5, we conclude our work developed for this dissertation, with some discussion about current limitations and future work.
Chapter 2

Related Work

2.1 Serious Games

2.1.1 What is a Serious Game?

They have been called by many names, "educational games", "educational simulations", "virtual experiences", "practiceware", "digital games based learning", "immersive learning simulations", "applied games" and more lately "Serious games". Throughout history, "Serious game" term has been used worldwide in different cultures, areas and with distinct meanings [Huizinga, 1951, Harfield, 2008, Soderberg, 2001] and to understand how it reached the gaming field we need to consider and understand its historical origin. We can trace the use of this term back to the Renaissance. Neo-Platonists used the term “serio ludere” to refer to the use of light-hearted humour in literature to handle serious matters [Manning, 2004]. The Closest meaning of this term in video games area seems to be dated to 1970 in Clarks abt book “Serious games” [Abt, 1970].

Even though Serious games have been used for more than forty years, research in this area is relatively new and hasn’t yet been established a common definition to the term. Abt was the first who gave a clear definition of Serious games, saying in his book that “Games may be played seriously or casually. We are concerned with Serious games in the sense that these games have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement. This does not mean that Serious games are not, or should not be, entertaining.” The most recent definitions reinforce this premise. Corti [2006] mentioned that “leverage the power of computer games to captivate and engage players/learners for a specific purpose such as to develop new knowledge or skills”. T. Susi and Backlund [2007], Breuer and Bente [2010], He and Hu [2010] present Serious games as “Computer games whose purpose doesn’t focus on entertainment, but in deliver educational meaningful information.” Aaron DeChamplain [2012] referred Serious games as interactive computer applications, engaging and fun to play, with a challenging goal, that imparts to the user a skill, knowledge, or attitude that can be applied beyond the play session, in the real world.

For many years people were reluctant about Serious games and their power to teach and train
learners, and that seems to be related with the dominance of the number of “entertainment” games in the market and the bad reputation of some of these games [Damien Djaouti, 2011]. Furthermore, still nowadays many people are confused about this term. This because “Serious” and “Games” are seen as opposite matters [Rua, 2013]. People relate games to entertainment and therefore are not treated as serious. Serious games compared to entertainment ones, are designed with the purpose of teaching something beyond the video game session experience and be applied in a real world situation. If the learning outcome stayed only strict to the game play space the education would be in question.

Different educational methods and perspectives have made difficult to prove the value of Serious games as learning tools. Some have doubts about learners needs be really met by games, but this is mostly because many times the evaluation method of the game goes against the usual teachers/instructor evaluation method, indicating game design problems, reducing this way, the value of that game as a learning tool [Murray Turoff and Yao, 2006]. Furthermore, arguments against Serious games have been centred upon a lack of clear standards, guidelines, adequate evaluation methods [Mitgutsch and Alvarado, 2012, Amri Yusoff, 2009] and an educational, theoretically founded and evidence-based framework that helps us understand how learning in serious games takes place [Clark, 2007], even with previous studies having already demonstrated positive results of game-based approaches over traditional learning techniques [van Eck, 2006, Knight, 2010].

Just like Serious games have no clear definition, there is no clear consensus if a game can fulfil learners needs as a good learning tool. Despite that, many researchers have been studying possibilities and game properties that have much to add to the traditional way of teaching, making people rethink the way that schools are teaching this new generation of students.

2.1.2 Why Video Games as learning tools?

Serious games have been around for many years and have already shown their potential as learning and training tools in several areas, such as education, defence, industrial, engineering, healthcare and therapy, art and culture, advertising, military applications, city planning, production, religion, Vehicle control (flying and driving simulators) and crisis response [Maria Saridaki, 2011]. Their rising interest have been proportional to almost every field, affording ultimately any application domain. Despite all the areas being interesting areas of research, in this document we are going to focus on Serious games for crisis response, and explore its impact in a classroom environment as well as its value to students, teachers and schools.

The widespread use of video games and internet and the need to create more, alternative and engaging educational practices have lead to the emergence of Serious games as a new way of teaching and training individuals. Depending on the context, these games aim virtually people of all ages, promoting their improvement as human beings and teaching new skills and knowledge to be applied in real world situations. Serious games are intentionally designed as learning experiences, that not just teach
game rules, narrative, fictions, metaphors and goals, but they teach players something new about the real world, themselves, their own attitudes, values and beliefs [Peng, 2010].

Audiovisual media provided by games, enhance the absorption of information in the students memory, improving considerably the learning process [Solanki, 2009]. Moreover, another factor for its beneficial effects is the presentation of the subject matter in form of a video game, which was found improve players concentration and attention [Kirriemuir, 2006] as well as information retention and increasing of learners motivation and learning experience.

Games that are not initially design as teaching tools can provide rich new experiences able to change and improve players lives. Even games usually described as violent, make players explore the environment, evaluate the possibility space, exercise power over it and change it. First person shooters like Call of Duty are all about memory, team work strategy, reaction time and judging more than a violent sharp-shooting, improving this way not just primitive skills but the ability to read maps, learn how to interpret symbols, evaluate risk, measure distances.

Video Games specially designed for educational purposes, reveal potential benefits of engaging and motivating students beyond the game session [Anderson and Freitas, 2009], improving socialization, collaboration, social skills and increasing self-monitoring, problem recognition and problem-solving, decision-making, better short-term and long-term memory, and shared decision-making [Sørensen, 2007].

**Students, Teachers and Schools need Serious games**

There are no doubt that video games are part of our culture as much as books, movies, television and other media, and just like this media, video games have the potential to be more than just entertainment [David R. Michael, 2006]. The new generation of students has grown up with them, and are used to it, reason why they are more likely to play video games and learn from video games [Sebastian Kelle and Specht, 2011]. In this world, full of distractions, students expect be engaged and emerged on what they are learning other wise they get distracted by other more engaging things. It is said that video games can engage players from 2 hours to 4 hours, while in the classroom students typically lose interest after 15 minutes, thus, Serious games could be an important tool to solve this issue [David R. Michael, 2006]. This show us a need for a change on delivery and organize the teaching material that have to be accommodated in order to meet the new students generation expectations [Reeves, January 2008]. Amri Yusoff [2009] believes that Serious games can provide a suitable solution to this spreading problem, meeting students needs and expectations while enhancing the traditional teaching support in the classroom.

Jane McGonigal in his 2011 book argued that reality is generally very unsatisfying, and that is the reason why many people find happiness increased in video game environments [McGonigal, 2011]. Video games was in the past regarded negatively making children addictive. Now this ability have been
used as a mean for educating children, enriching their everyday lives, and improving happiness and fulfillment while learning voluntarily [Suits, 2005]. Students become motivated to learn on their own when they can relate almost instantly what is being taught and its practical appliance, manipulation and consequences, and when they can see his application in their daily lives [Mitgutsch and Alvarado, 2012].

Many students consider learning in school boring, much this because they take it seriously and not as a practice activity with grades and social standing. Our brain is a learning machine, it wants to learn all the time, to ensure our survival and to better adapt us in this world in constant change. However when pushed by someone to learn, it seems show some resistance. Furthermore, our brain is made to optimize what we are doing. However traditional teaching goes against that, asking students to write down everything even if they know the answer in advance.

There is a rising demand by teachers for new and innovative ways of teaching. Special attention is being paid to the potential usage of Serious games and their ability to inform and transfer knowledge in a more engaging way. For a more effective learning process, it is important design Serious games recognizing the educational/ instructional objectives and plans while on the other hand teachers must make their plans considering Serious games, and be prepared for it. Serious games can be used in the classroom to learn a new topic for the first time or at home to reinforce what was learned in class. All teachers want the best for their students, searching for more effective ways to transmit and retain new information. With this in mind, researches affirm that video games can have positive cognitive, attitudinal and behavioral effects on players, leading to a positive learning outcome going through students and teachers expectations [Elizabeth A. Boyle and Boyle, 2012, Egenfeldt-Nielsen, 2006].

Schools have much to gain with Serious games, allowing learners to experience situations and learn from them in a way that it is difficult or even currently impossible to achieve in real world due to factors such as cost, time and safety concerns [Aaron DeChamplain, 2012]. They offer a low cost, highly engaging alternative to the traditional learning form [Conor Linehan, 2009], without stopping the normal school schedule, and with no need of specialized personal.

Serious games and traditional teaching comparison

When designing games for educational purposes is important to compare their characteristics with traditional teaching, in order to understand how they are similar and where they diverge.

The similarities between these two educational methods are the following ones [David R. Michael, 2006]: (i) students must be immersed, with attention of what is being taught in order to successfully learn the material, (ii) teaching is based on rules, (iii) students are often asked to apply that knowledge through repeated exercises to make sure that what was taught was learned and remembered, (iv) social groups are created to encourage communication, sharing of knowledge and problem solving, (v) teaching happen in a specific time and space, and (vi) the material is presented in small pieces in order to not overwhelm the students. In the same way, as well as what happens in traditional teaching, games
require the player to learn something, at the minimum the rules of how to play, and once the basic rules are mastered, then comes refinement through trying different strategies and ways of applying the rules.

Serious games and traditional teaching have the same way some differences. Serious games objective is to get voluntary players to learn what they have to teach, and if possible have fun in the process, the traditional way of instruct students is not a voluntary attendance and enjoyment and fun is not a requirement but regardless these differences, education and entertainment are not in conflict [David R. Michael, 2006]. There are many situations where they overlap and where both can use the tools of the other in order to improve and achieve their objectives.

2.1.3 Designing Serious games

There is some scepticism about if a Serious game should be fun and if there is room for fun in education, that probably because mostly people misunderstand the term. Raph Koster, in Theory Of Fun, defined fun as a consequence of learning something new, pointing this feeling as a positive feedback from our brain when we are learning and understanding new things, what get us to repeat the activity voluntarily over and over again [Koster, 2005]. So based on this definition we can say that games and education have much to gain with fun in order to effectively teach players/learners and motivate them to play and learn on their own.

In order design Serious games the best learning experience possible and meet humans expectations, first we need to understand how, why and where we learn.

How we learn

It Is said that children learn faster than adults and there is a believed reason for that. According to Koster, early aged children seem that can’t learn by being taught, instead they learn by trying over and over again, doing mistakes and evaluating the outcome of their actions. Based on that and regardless how old we are, repeating a task several times, observing our actions doing it and evaluate the respective outcome can effectively improve our understanding and reduce the reaction time doing it.

Why we learn

We are constantly learning probably because our endless demand for adaptation in a contextual world in constant change. Koster, is his book theory of fun described fun as our brain rewarding us for practising and learning with an contextual reason. The purpose why we are doing a task matters a lot, being that exercising mastery over something, achieving a significant task, survival, breaking a personal record, a mentor recognition, social enhancement, win against an opponent or make our farm more profitable. This is why rewards are one of the key elements of a successful game play session, the player needs to find any advantage of doing something, otherwise he probably will discard it. On the opposite side we have boredom, the feeling that our brain send to us when the game stops teaching us and there are no more new information to be absorbed.
Who are going to learn

It is well known that men and women brains works differently, and when designing video games it is important to know how different they are while playing video games, in order to give the best experience possible in each case. Men are usually better in spatial perception while women are better in language. In terms of preference, women have choice for games that emphasize interpersonal relationships, narrative and empathy and dislike strict hierarchies while man like games that involve power and control of territory. Although, these are the usually individual traits of each gender, they can be permanently changed through video games.

Where and when we learn

We are learning at all time and everywhere. In his book, Koster refers that if we do any task many times, we get used to it in a way that we came up doing it without even knowing how we did it. An easy example of that is that we can drive or dress without remembering has done it. Every task done in autopilot is called a routine, and it is a patterns that our brain recognize, expecting to be the same as before, making assumptions about the surrounding world, constructing a simplistic one that cuts all the irrelevant information, to be easy to process.

Tasks that are not routines are quite inefficient, being the reaction time doing it mush slower than when done in autopilot. We see this all the time, where people are driving and something unexpected happen, leading many times to a car crash. In this situation the driver have to think and switch from autopilot and thinking about how to handle the unexpected problem, being his reaction time much lower not just by the thinking itself but by the switch.

In conclusion, as Koster said "Fun is a journey and the routine is the destination”. The more we practice the less we have to think about what we are doing, being the ultimate goal of learning turn something we learn into a routine.

Elements of design

When designing Serious games we must have in count not just how, why and where we learn but which game design elements are able to put that theory into practice. In order world, which aspects of game design will help us to have a better learning experience through video games. Some researchers have already pointed the following components as some of the fundamental ones that a Serious game must cover in order to successfully be used as a learning tool.

Preparation: Before taking on a given challenge, the player gets to make some choices that affect their odds of success, having freedom do prepare in different ways and still be succeed.

A sense of space: Is important that the environment in with the challenge takes place affect the challenge.
**A solid core mechanic:** A game is a problem to solve with an intrinsically set of clear rules, that have to support different types of challenges.

**A range of challenges:** It is important to have multiple ways to overcome the same challenge, as well as several challenges with different approaches that can be overcome exploring different possibilities but never changing the rules.

**A range of abilities to solve a problem:** Every time the player is facing a problem he must have a set of abilities that can be use in order to solve it. If just one ability available to solve the problem or if skill is not required to it, the problem is considered as trivial, on the other hand if lots of abilities are available the possibility space create a more complex and interesting problem to be solved. Most games unfold abilities over time, until at the high levels where the player have to choose from many possible strategies to solve the problem.

**Punishment:** While facing a problem, bad choices must lead to a some kind of penalty, such as lose health, score, time, money or any other asset that have value to the player ultimately fail the encounter and making him do it again, losing not just the time spent on the game but the goods gained as well.

**A variable feedback system:** the response of the encounter should not be completely predictable. Ideally greater skill in completing a challenge should lead to better rewards.

**Balance difficulty:** The Video game should not be too easy for hardcore gamers non too difficult to inexpert players.

As we already know, boredom is responsible for ceasing the enjoyable experience of learning, and knowing this, research point some techniques that help developers to avoid premature boringness in their games:

**Fast understanding:** The player might understand how the game works within the first 5 minutes and the game must not be considered too easy.

**Game depth:** The game must offer enough depth so the player can try different approaches but all them are below their level of interest.

**Pacing variations:** The game must not unveil variations too slow, otherwise the game can be dismissed as trivial too early, nor too quickly, which leads to players losing control of the game and giving up because it looks confused.

**The end:** The player must leave the game when it as nothing more to teach, the player consumed all the fun, and mastered everything.

**Unpredictability:** Humans dislike and avoid unpredictable situations by nature, is our survival instinct, however we dislike tedium too what allow us to enjoy unpredictable situations under predictable conditions like games and TV shows. Each unpredictable situation gives us new things to learn and therefore unpredictability is fun under conditions where we ate not at risk.
In conclusion, is not expected that a Serious game cover all this elements, and one alone is not enough to guaranty the desired outcome from the experience, however several of this elements together can effectively be able to improve the learning process expected through games. In order to avoid boredom the design must be made to carry the player learning, so the game continue to be fun and the player stays playing.

### 2.2 Earthquakes preparedness

Natural hazards are a worldwide concern now more than ever before. In a world where population is continually expanding, cities follow this growth, leading to a rising concern about natural and man-made disasters. A natural disaster like an earthquake can easily put a country in a devastating situation, taking lives and affecting its economy for a very long time. Not just city buildings are in risk [Vere-Jones, 1995], critical facilities such nuclear reactors can affect not just the country where it is installed but all the other countries around it, being considered an intercontinental concern.

Science has been trying to predict earthquake occurrences diagnosing its precursors from the principles of location, date and magnitude with no success. Because is not possible to predict where and when an seismic activity will occur, and to minimize the damages, is imperative be prepared. Fulfilment of some very simple standard rules before, during and after an earthquake can be a definitive factor to reduce injuries and material damages.

With the help of Department of Civil Engineering of Instituto Superior Técnico and with the information online available by American Red Cross\(^1\), Ready\(^2\) and Instituto Português do Mar e da Atmosfera (IPMA)\(^3\), 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.

#### 2.2.1 What to do before an earthquake?

Before and earthquake people should get informed and warn their families about earthquake consequences and be prepared for such event, planning and taking some simple measures and construction solutions in order to minimize damages and injuries to their property and to themselves.

**Plan for an Earthquake**

Plans make people think about the consequences, what to do to prevent some of them and how to behave in the real event, resulting in a more calmly and accurate response to a seismic occurrence. Following are some of the main plan topic to take in consideration:

**Gather the family:** Any member of the family aware of earthquakes danger, should gather the family and share knowledge about risks and procedures. Is crucial that everyone knows what

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\(^1\) [http://www.redcross.org/prepare/disaster/earthquake](http://www.redcross.org/prepare/disaster/earthquake)

\(^2\) [http://www.ready.gov/earthquakes](http://www.ready.gov/earthquakes)

to do when an earthquake strikes. Everyone must be informed about the risk in his area of residence and know the emergency plan of each building where they go, as well as think about the particular needs of infants and people who need special care, and make a plan with their needs in consideration.

**Identify places:** All family together must know where safe and dangerous places are, in order to improve their reaction time and avoid injuries. The safest places usually are: Corners of the supporting walls, under the tables and beds, while the dangerous ones are objects that can fall, break or splinter like windows mirrors, ceiling lamps and high-shelves.

**Any time and anywhere:** People must think about earthquake consequences and the behaviour to take in such hypothetical case of it strikes at day, night, in home, in other peoples house, in work, street, public transport, driving, in a mall, cinema and any other places.

**Know the after-effects:** Is highly important that everyone knows the most common earthquake after-effects that can occur in their home - passageways and house conditions can substantially change after its occurrence. Earthquake after-effects can lead to a gas leak that can intoxicate residents or provoke an explosion and electric wires can block our passage or ignite fire, and water leak can cause floods and block the way. So it is essential that all family knows how to turn off the water, gas and the electricity, and know how to keep passageways as free as possible.

**Plan a meeting place:** Together, everyone must talk about an emergency plan and about a meeting place. During and after an earthquake people can get lost and 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 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 and are directly unreachable.

**Build an Emergency kit:** All family must be encouraged to build an emergency kit together, so everyone knows how to do it and which objects are essential to survive. Following a disaster, having extra stock at home or supplies to take in the event of an evacuation 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. 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 prescripted medications.
• Credit card and cash.
• Personal identification and important documents, or at least copy thereof.
• An extra set of car keys.
• Matches in a waterproof container.
• Signal flare.
• Emergency contacts including police, fire, nearest hospital, and family.
• Entertainment, such as small portable games (e.g. card decks) and books.
• 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, towelettes, soap, hand sanitizer, liquid detergent, disinfectant, feminine supplies, shampoo, deodorant, toothpaste, toothbrushes, comb and brush and medium-sized plastic bucket.
• Kitchen accessories such as can opener; paper cups, plates, and plastic/disposable utensils, utility knife, sugar, salt, matches and a portable stove.

Should be take special concern 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, family needs change over time.

**Easy access:** People should know where emergency exits are, and keys must be placed close to the respective doors, to 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. Is recommended to always keep an handy and operating flashlight, especially near the bed, because earthquakes can strike at any time. Operational extinguishers should be placed near to places where there is high risk of fire, to a more fast and handy response.

**Property Protection**

It is said that ounce of prevention is worth a pound of cure. Following this premise, and due to the unpredictable nature of a seismic occurrence, in order to protect their property, residents should adopt some measures to improve the overall safety in their home. Some of them are simple actions
that require low cost items, while others are a bit more expensive but quite efficient. Either way both are equally important, solving different problems.

Simple measures

All family should know how to improve the overall safety in their home with very simple measures that can go from simply tying shelves, vases and other objects that can fall until placing heavy objects in lower shelves.

**High, top-heavy and fragile objects** such as televisions, pictures and mirrors must be put away from beds, couches, and other places where people sit or spend most of their time. An earthquake can strike and knock things off the walls, damaging property and injuring residents.

**Large, heavy and breakable items in high-shelves** such as books, plates, and glass made objects must be moved to lower ones or preferentially lower closed cabinets with latches. There will be less damage and less chance of injury if these items are close to the floor or kept inside cabinets with strong latches or bolts.

**Chemical products** such as weed killers, pesticides, and flammable products should be secured in closed cabinets with latches or in bottom shelves, this way will be less likely to create hazardous situations, like a fire.

**Residents must check** if all ceiling lamps are fixed and if heavy objects stability are not threatened by an earthquake occurrence. Vases of loose flowers should not be put in windowsills, they must be conveniently attach or by preference removed and placed in the floor.

Construction measures

The damages produced by earthquakes can be highly reduced when applied construction earthquake-resistant, a preventive measure that usually doesn't go over 10% of the total construction price. Some of the measures rests in installing flexible pipe fittings to reduce or avoid gas or water leaks and strap the water heater to wall studs, because it may be the best source of drinkable water following an earthquake.

**Residentes should repair** any deep cracks in ceilings or foundations and get expert advice if there are any signs of structural defects, because an earthquake can turn cracks into ruptures and converte smaller problems into bigger ones.

**People must know** if their house is bolted to its foundation and the risk they are taking if it is not. Homes bolted to their foundations are less likely to be severely damaged during earthquakes. Homes that are not bolted have been known to slide off their foundations, and many have been destroyed or became uninhabitable.

**In Home or at the workplace** people must look for elements that can fall like chimneys, tiles,
cornices, antennas, solar panels, water tanks and other similar structures and check if they are correctly placed and fixed, if not, they must be fixed as soon as possible.

**Residents must consider** having their building evaluated by a professional structural design engineer and ask about home repair and strengthening tips for exterior features, such as porches, front and back decks, sliding glass doors, canopies, carports, and garage doors.

### 2.2.2 What to do during an earthquake?

During an earthquake some people get apathetic, paralysed 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 behaviours to take in the real event. What to do during an earthquake highly depends of where the person is:

**If Indoors**

If in home or inside of a building residents behaviour 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 don’t rush to elevators or stairs. Otherwise if in a 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 behaviours to take when the earth shake 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 they take less likely 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 there are complete certainty that is a strongly supported, load-bearing doorway and it is close, 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 an 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 electronic devices might not work as were supposed making sprinkler systems or fire alarms may 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 can 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**

Individuals 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 is much 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 must be taken special attention to the olden and isolated ones and move quickly away from them to prevent injury from falling debris. Is not recommended running or hanging around in streets, because walls, chimneys, balconies, trees, streetlights, power lines, and other objects can collapse.

**If Driving**

When an earthquake strikes, people that are driving should pull over the vehicle to a clear location far away from buildings, walls, electricity pylons, high voltage cables, trees, overpasses, underpasses, utility wires and stay inside the vehicle with the seatbelt fastened until the shaking has stopped. Stopping will help reduce the risk, and a hard-topped vehicle will serve as a protection against flying and falling objects. If a power line falls over the vehicle, is not recommended to get out, but wait for assistance. Once the shaking has stopped, drivers can proceed with caution, avoiding bridges, ramps and roads that might have been damaged by the earthquake.

**If In a boat near to the coast**

After a huge earthquake a tsunami is usually expected. These colossal waves are most dangerous when less depth, being considered 150 meters the a minimum safe depth where a boat must be, being the ideal 400 meters. Individuals must know that may be more than one destructive wave with variable sizes and they can be separate from each other in intervals of 20-40 minutes in exceptional cases for several hours. Even if the waves are not very high, they are extremely lethal, because of their complex currents and large amount of debris. For this reason, the return to the cost must be done only after maritime authorities permission.

### 2.2.3 What to do after an earthquake?

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

If Indoors

People must stay indoors until the shaking stops and stay calm, most injuries happen when people move during the shaking of 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 can fall over them as well as stairs and floors and them 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 cannot hold much longer. Elevators must never be used, aftershocks, power outages or damages might let it stuck, stairs must be used instead after evaluated its conditions.

Matches and lighters should never be used, a gas leak can happen and the flame can 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 go through places with loose electrical wires, and must use a cellphone just in very urgent situations like highly injured, gas leak or fire.

If trapped under debris

In the case of people get stuck and can’t leave the building, they should rapidly find some help to go outside. In case of get trapped under debris, individuals should be extra careful and know some quite simple attitudes to take in order to ensure their survival. Trying to move can result in collapsing the remaining debris or raising dust, becoming breathing more difficult. Shouting for help must be used only as a last resource or when we are sure that we are going to be lessened, because can cause inhalation of dangerous amounts of dust. Instead people must slowly breath, cover their mouth with a handkerchief or clothing and tap on a pipe or wall, or if available use a whistle so rescuers can find their location. If we are injured we must try to stanch our wounds and stay warmed.

If Outdoors

Natural disasters such as earthquakes often result in extensive casualties and damage and there are no generic evacuation procedure to take in natural hazards neither for the specific case of earthquakes. People evacuation behavior depends of geographical characteristics [Cheng-An Tai and Lin, 2010, Yamori, 2011]. For this reason, after an earthquake, residents must follow the instructions from Authorities of urban transportation traffic evacuation, they should adopt essential measures to secure pedestrians and roads besides vehicles. [Cheng-An Tai and Lin, 2010] Some
roads may be blocked, bridges damaged, and some buildings may collapse [Chen Bin, 2009]. So due to the threat of aftershocks, residents must avoid activities in buildings and in case of their home had been damaged and is no longer safe, they should go to a designated public shelter and return home only when authorities say it is safe. Individuals should not hanging around in the street and they must watch out for fallen power lines or broken gas lines, and stay out of damaged areas. When driving, after an earthquake and individuals should anticipate traffic light outages, and roads blocked. If we don’t know the whereabouts of people that we know, we must inform authorities and contact our contact person to get information and take account of overall situation of your family.

If in the sea or on the coast

In the sea or on the coast, “during” instructions previously mentioned remain valid until authorities inform that there is no more danger.

First days after the event

After it is determined that it is safe to return home, our safety should be our primary priority. First, is recommended to wear some protected clothing such as long pants, a long-sleeved shirt, sturdy shoes and work gloves to protect us against injury from broken objects, and next as good citizens, help people who may require assistance, such as infants, children, elderly, large families and disabled people. In case of spot an injured or trapped person an emergency call must be made followed by first aid assistance when appropriate. Seriously injured people must not be moved unless they are in immediate danger of further injury.

When entering in buildings, individuals should take extreme caution, building damage may occur where we least expect it, and smoking inside should be avoided, because in confined areas it can cause fire or an explosion. Fire is the most common hazard after an earthquake, so we must look around for and extinguish small fires. If we are unable to extinguish the fire we must call the fire department. It is also important remember to take pictures of the damage for insurance claims. We must inspect our home for damage, examining walls, floors, doors, staircases, and windows to make sure that the building is not in danger of collapsing, and get everyone out if it is unsafe to stay inside. We should watch for loose plaster, drywall, and ceilings that might fall, as well as carefully inspect the entire length of chimneys for damage. Cracks in chimneys can be the cause of a fire or injury from falling debris during an aftershock or even many years later. Closet and cabinet doors must be cautiously open with beware of inside objects may have shifted during the shaking of an earthquake and could fall, and create further damage or injury. We should clean up spilled medicines, bleaches, gasoline or other flammable liquids and in case of smelling gas or fumes from chemicals, we should leave the building immediately.

We should not use electrical switches without first having sure that there is no gas leak. Almost
imperceptible small sparks resulting from the use of switches may ignite the gas coming from damaged pipes, for this reason, if we smell gas, we must open up the windows and evacuate the building for safety, call for the gas company, from anywhere but the building in danger and notify the rescue team when they arrive. For this reason, we must use battery-powered lanterns or flashlights to inspect our home. Kerosene lanterns, torches, candles, and matches may tip over or ignite flammables inside. If possible before leaving the house, the gas should be turned off at the outside main valve and it must be turned back on just by a professional. Explosions have caused injury and death when homeowners have improperly turned their gas back on by themselves.

We must look for electrical system damage, and in the case of sparks or broken wires be seen, if it is safe, we must turn off the electricity at the main fuse box. In case of being too risky a call for an electrician must be made for advice. We must take a look and check for sewage and water lines damage, and in case of doubt about its condition, toilets usage must be avoided and a plumber should be called. In case of water pipes had been damaged, the water company must be contacted, and usage of water from the tap must be avoided, could safe water be obtained by melting ice cubes and from undamaged water heaters. After security be secured and people back to their homes, comes a stage where people who experienced the earthquake get emotionally altered, suffering from panic attacks, nervousness, anxiety, fear, confusion, physical numbness, disorientation, vomiting, abdominal pain, loss of appetite, insomnia and irritation. Children are one of the more sensible group of our society. After an earthquake is very important to speak with them and lessen their worries, is crucial for them to let their thought get out, so lessen and let them present their thoughts through drawings.

2.2.4 Preparedness in schools

Serious games in education have yet been seen as and 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 [Izadkhah and Hosseini, 2006].

One issue that needs some consideration is that most teachers are not qualified to teach about earthquakes and the proper behaviour to take in such situation. They usually, don’t follow any uniform standard guideline, instead they use their own creative ways of teaching based on books or previous experiences. The teaching of this topic depends many times on their personal interest and creativity to motivate students. This means that having enthusiastic teachers is very important in order to create enthusiastic students capable to retain and spread the topic [Izadkhah and Hosseini, 2006].

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 as 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 this issues [Izadkhah and Hosseini, 2006].

Children in school are usually excited to participate in drills, being believed to be one of the most favourite activities among children [FEMA, 1990, Izadkhah, 2004]. 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 be created by the school, being spent time and sometimes qualified people for this occasion.

Serious games would bring many advantages to 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 [Squire and Jenkins, 2003]. 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, and put the player in the situation with lack and incomplete information, in a dynamic, complex and non deterministic environment that change over time, with limited time just like in real situations [Qi and Lei, 2009].

2.2.5 Already existing Serious games and their analysis

Although a growing body of literature suggests positive effects of video game play on learning in various contexts, the number of studies testing the potential of these games in earthquakes risk, prevention and self-safety behaviour context is still very limited. Literature suggests that video game positive effects depend on how the game features are designed and how the player interact with them. The same way, well designed video focused in natural hazards and earthquakes in particular may increase awareness of its causes and consequences and provide players with basic knowledge and skills to take the necessary precautions. [Zeynep Tanes, 2013]

Next, we present some Serious games that in some way teach, inform or sensitize people for earthquake consequences and the behaviour to take in such situation.

The Day The Earth Shook

The Day The Earth Shook is a 3D Serious game created by Illinois Emergency Management Agency along with the Electronic Visualization Lab at the University of Illinois whose purpose is to inform middle school students about earthquake emergency preparedness, teaching seismic consequences, how to make an emergency kit, and where safe and dangerous places are. The player starts the game by selecting character, a boy or a girl. After that an alien hovering down out of a blue sky to the selected child, warning him that he needs to be prepared for an earthquake and pop a pair of special glasses on the characters face. This game have a strict sequence of events that must be done in order to proceed in the story and end the game. First, in third view the player have to wander in home looking for items to

4http://www.state.il.us/ilema/EarthquakeGame/Play the Game.html
fill his earthquake preparedness kit, next an earthquake strikes and the player have to spot dangerous and safe places, and at last a house fire where objects fall and there is smoke blocking the way. The game ends when the character leaves his home after surviving the house fire with a total duration that can go from 15 to 30 minutes depending on the player skill.

![Image from The Day The Earth Shook.](http://www.dropcoverholdon.org/beatthequake/game/)

Figure 2.1: Image from The Day The Earth Shook.

The Day the earth Shook from learning point of view is a game with a range of challenges that meet its pedagogical goals. However some messages sent through this game can be easily misunderstood because of their bad implementation - The game asks the player to wander in his house while the earth is shaking and find dangerous places, the earthquake can stay forever shaking the house without any consequence to the player, and he is playing under a simulated safe environment created by the alien, something that doesn't happen in real life and goes against the under-pressure problem solving needed in this kind of situations. From gameplay point of view, the character control don't feel natural breaking the immersiveness, moreover the poor ascetics, the predictability of the game and the absence of variations make the game less engaging and boring, demotivating the players to repeat new iterations of the game.

**Beat the Quake!**

*Beat the Quake*[^1] is a 2006 Serious game designed by Earthquake Country Alliance as part of the earthquake readiness campaign in California. The game educational goal is to teach players how to secure objects in home, creating a safer place and reducing material damages. In this puzzle game, the player must identify correctly how to secure the 14 objects displayed on the virtual living room, clicking and choosing the appropriated methods and tools. Each object has a quiz and the player must choose which option is the correct to secure the object. Throughout the game, the player receives audio, visual, and textual feedback in order to instruct and engage the player. The more items the player correctly secures, the higher score he receives. The game duration depends on the level of activity on the screen but the game comes to an end within 2 to 5 minutes, when a huge earthquake strikes. After that, the player have yet options to inform friends about the game, get more information from web sites or play again.

[^1]: http://www.dropcoverholdon.org/beatthequake/game/
Beat the Quake, is a game with a simple and solid game play mechanic and quite easy to understand - controlled by mouse click, with instructions at the beginning of the game and with a clean interface. This game give freedom to choose what and how to secure objects and see the consequences of their choices. The seismic occurrence in this game offer the unpredictability expected in this kind of event. Unfortunately the game just covers a part of what is really required to ensure better odds of survival, being focused in securing our goods in the leaving room.

Disaster Hero

Disaster Hero is a web-based game developed by American College of Emergency Physicians (ACEP), where the player can face four different natural disasters earthquakes, tornadoes, hurricanes, and floods. Designed to teach children (grades 1 through 8), parents, and teachers how to prepare for disasters, the goals in this game are to ensure that players know how to act before, during, and after a disaster. The game opens as a television show, where the player has to prove that he can be the next disaster hero. In this 2D point and click game, the player faces different minigames in order to progress in the game. Each disaster is represented by a CPU’s character, and the player starts by choosing against which CPU is going to play. Next he faces a minigame where he has to get symbols and answerer a quiz about the selected disaster. After answering the questions, the player enters in a menu where he selects the desired minigame available for that natural disaster. In the earthquake’s case the minigames explore making a plan, getting a kit as well as before, during or after earthquake situations among others that prepare players to the real thing. Minigames are different from each other, but with the same structure, every time the player select a correct object or do an appropriate action, a visual information about the proper procedure is revealed followed by the corresponding voice acting. The time of play relies on player’s skill and depends if the player reads and listens everything or skips information, but it can easily go over 30 minutes.

Disaster Hero, cover the 3 phases of an earthquake event, give us some sense of unpredictability and variation, and give us a wide range of challenges. However the game don’t give the players a sense of preparation, this means that regardless what we do before an earthquake strike, have no

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6http://www.disasterhero.com/
consequences during and after it. The game offers the player lots of feedback and information with voice acting, however most of this can be skipped, being the player able to finish the game without even reading or lessening any information. Some mini games don’t emerge the player into the environment of a seismic activity - A example of that is the minigame to teach to drop, cover and hold, where the player have to play a game like Puzzle Bubble, a game that doesn’t give the environment required neither the experience expected to have in such event.

Disaster Master

Disaster Mater is a game made by Ready, an American public service advertising campaign designed to educate, empower and prepare people for natural and man-made disasters. This Serious game is an interactive graphic novel where the player, while reading the story, have to make important decisions in order to proceed. Making the right decisions the player earn points and energy, whoever wrong choices make the player lose energy and when there is no energy left the game ends. In this game the player has to go trough several levels each on representing one disaster situation: wildfire, tornado, hurricane & blackout, home fire, winter storm & extreme cold, tsunami & earthquake, thunderstorm & lightning and at last a hot seat, in this order, with a duration of more or less 5 minutes each case. To go trough a specific disaster the player has to pass through all the previous ones and unlock a

\[\text{http://www.ready.gov/kids/games/data/dm-english/index.html} \]
password to get access to the next level.

Figure 2.5: Image from Build a kit.

In addition to this game Ready made one other named Build a kit\(^8\). Its educational goal is to inform people which objects they must have in their emergency kit, instructing where to find them and why they need them. In this game the player has to search in different places for useful objects to carry in the emergency kit. If any of the objects selected is wrong or if there is some important object that was not selected, the game inform which ones were correct and which the player doesn’t need of are missing. If that happen, the player has to start that place again with an empty kit even if some of the objects were right. When on the current place, there is no more correct objects to take, the player can move to the next, this until there is no more places to go.

Disaster Master, is a simple game, with simple core mechanics thereby easy to understand and stay emerged. Still, is more a graphic novel than a game, giving the same experience, every time the player try the game with any kind of unpredictability and variations, thus with nothing new to learn. In terms of learning the game just explore the during and after faces of an earthquake, and the player choices have no implications in the story development, the player can successfully end the game doing everything wrong, failing giving to the player a purpose of doing it. Moreover The player has to complete all previous disasters to get to the desired disaster at least one time and get the password to move on, if schools want to teach just earthquakes to students, they have to do all the disasters before, or know the password, and if the password is lost, the player has to do all the disasters again until getting the disaster he wants to study.

Earthquake Survival

Earthquake Survival\(^9\) is a game made by wowgame\(^10\), whose purpose is to teach how to behave during an earthquake, and which objects must be take in count, and for which purpose. In this game the player controls a little girl in her home during an earthquake. The player moves the character through the room, while for 60 seconds face several earthquake consequences like, fires, and furniture and ceiling falls. The character has an health bar and must avoid dangerous situations and use the emergency kit, open

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\(^8\)http://www.ready.gov/kids/games/data/bak-english/index.html
\(^9\)http://www.purely-games.com/earthquake_game.html
\(^10\)http://www.wowgame.jp
windows and doors, among others to survive and go to the next level. In order to inform the player what
he has to do, the game gives visual and audio feedback, important objects start flashing every time that
is supposed to do something with them. When that happens the player should move towards them to
find out what happens next. For example, when fires break out, the fire extinguisher starts flashing, and
the player should go get it and then move to where the fire is, to extinguish it. The same way when the
table flashes the player should go to it and protect himself. This game is freely available to everyone in
several websites, however just in Japanese.

![Image from Earthquake Survival.](image)

The Earthquake Survival give the player good feedback of what is expected to do, giving the player
short-term goals, but lack in giving it some kind of preparation before the earthquake. There are some
points that can go against the desired engagement. The earthquake never stops, what is an unrealistic
situation, and the player can just choose as a playable character a little girl what can make it difficult
to the player to project himself into the character and relate what is happening to him if he have the
opposite sex. In terms of learning, the game sometimes ask the player to do things that can go against
common procedures, jeopardizing its educational value. For example during the seismic activity the
game asks the player to get close to a window to open it, to wander by her room to get the emergency
kit, open the door, extinguish a fire and much more other dangerous things that must be avoided and
sought protection instead.

### 2.3 Previous games analysis

As we saw before, all previous games have as main goal teaching procedures to take in case the earth
shakes. However they present the same topic with distinct design techniques, aspect and different
approaches to the pedagogical content:

**Presentation:** Disaster Master is a 2D game presented in cartoon style with a very polished, clean and credible
appearance - The game display everything like a television cartoon or comic both things that
children are used to, and present facial expressions revealing the natural emotions that is expected
to feel in such event, improving the credibility and the engagement. Choosing a cartoon style have
many advantages - The games age better than if it were made with a realistic appearance, are
pleasant to human eye and use iconic representations of real world objects that are simpler to our brain to process leading this way to a easier understanding of the learning content. This take us to point this game as the better alternative among the others for our targeted audience.

**Objectives:** Even if the main goal of these games are teaching correct procedures to take before during and after, not all games explore the tree scenarios, and even the games that do it, follow different paths:

---

- **Before:** On one hand, The Day The Earth Shook and Disaster Master teach the player the importance of having an emergency kit, which objects we should take in it and how to build one. On the other hand, Beat The quake! teach how to secure our goods, in order to maintain them stable while the ground is shaking.

- **During:** This state is where the games mostly diverge. In The Day The Earth Shook the player have to find safe and unsafe places during the earthquake with no consequences, instead of find a safe place and cover drop and hold until the shaking stops, situation that goes against the correct procedures that the game is suppose to send. The same happens in Earthquake Survival, where the player must hanging around during the seismic event extinguishing fires, finding first aid kits and protector helmets and opening windows and doors. Situation that in real life put individuals in great danger. Disaster hero, on the other hand, shows the common procedures to take, but unfortunately the player can't make a choice of doing it wrong. Regardless the game, the player can see the after effects that the earthquake have in their home.

- **After:** In the tire state of the event, The day the Earth Shook, show us the most common consequences of an earthquake, fire. After an earthquake the player must try leave home, crawling across the floor, to avoid inhale smoke, and avoid falling ceiling pieces. The Disaster Master show briefly some things that must be avoided such as walls and electrical wires and to take aftershocks in consideration. Both games show the player that must leave home, but never before the shaking stops.

---

**Gameplay:** Earthquake Survival is probably the game with best gameplay for our target audience. With a perspective view of the scene, simple controls(just the keyboard arrows) and almost no text at all, this game make children explore by trial error, that as we saw before in this document is the natural way of learning. Moreover, this game is a low time consuming game with a very addictive background music, leading players to try new experiences in the game, and reinforce what was previously taught.

**Interface:** All the games above present distinct interfaces, being some simpler than others, and displaying different information. In The Day The Earth Shock, the game shows where the dangerous and safest places are, painting a red geometric form in the floor for bad places and a different green to the good ones. However the Disaster Hero interface is probably the best among all the others, the player have lots of useful but skippable information available followed by the respective voice
acting feedback. The game shows the 3 distinct acts of the event, before, during and after an earthquake and give a piece of information every time the player do something Wright.

On the table 2.1 on page 28 we describe the usage of some of the design properties previously mentioned in this document and which are being applied in each game in order to improve the learning process.

In conclusion, each game have their pros and cons, all games but Beat the Quake! fail giving the player some kind of preparation that change the odds of success before the earthquake strikes, and most games fail give the unpredictability specially required when simulating a real world event that is unpredictable by nature. Most games are low time consuming what would promote repetition if not the low content depth leading to a situation where the players have no much different approaches to solve the same problem when try it again.

2.4 Related Works Conclusions

Now that we have our related work done we can point some important lessons that can be applied in our solution.

To make a successful Serious game we must start by defining our goals based on DCE objectives and then design a gameplay that goes along with those. These goals hold just by themselves, valuable learning elements related to earthquake preparedness that will serve as a base to our game. Thus, just by playing the game, the player will be aware of earthquake’s dangers and will better understand common procedures, becoming better prepared for the real event.

To do this we first have to gather all the information, facts, actions, reactions, relations and consequences and turn them into playable elements. Next we will find which of these turned elements can be transformed into gameplay elements and at last we will design the gameplay based on this elements turning them into rules and mechanics.

Furthermore, in our solution we intend to design our game based on what was presented on Section 2.1.3 and use those elements of design to help us to achieve a good learning experience.

Finally, after analysing the previous Serious games, there were some important lessons learned that can be used in our game: (i) because most of their targeted audience is young people, to appeal them, they opt by presenting the game in cartoon style, (ii) most cases they use very simple controls to be easy to pick and start learning, (iv) most of the games covered the three phases of earthquake preparedness and (v) some games explore different house divisions.
<table>
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<th>Disaster hero</th>
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Chapter 3

Video Game Implementation

3.1 Treme-treme’s overview

Treme-treme is a 2D game with two levels played in single player. In the first level 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 after 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 stop. 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.

![Figure 3.1: Treme-treme’s second level. The character is close to a valve and must interact with it to turn off the gas.](image)

Because the targeted audience for this game is very young individuals, the information about earthquake preparedness has to be simplified and covered in a way that they could understand. It is expected that after playing this game children have retained the importance of earthquake preparedness and the
risks of a major seismic activity, have learned how to build an emergency kit, where the safest and most
dangerous places are, and what to do before, during and after an earthquake.

### 3.2 Creating a Serious Game

The implementation of Treme-treme passed through three distinct but equally important phases:

- **First** - Based on the messages that DCE wanted to transmit, we started by defining the objectives;
- **Second** - We found the playable elements within the earthquake preparedness context so they could be transformed into gameplay elements;
- **Third** - At last, we design the gameplay, converting the playable elements into gameplay rules and mechanics.

#### 3.2.1 Defining goals

Based on DCE messages intended to be transmitted in this game we were able to define the following set of goals, used in our implementation and respective evaluation:

1. The player must know how to build an emergency kit and which objects are fundamental to put in and which are not;
2. The player should know how to act in each situation and what the dangerous and safe places are;
3. The player must be aware that gas valves and electrical switches must be turned off before leaving home;
4. The player must understand the importance of leaving home after an earthquake to his family emergency meeting point far away from buildings;
5. Players must understand how dangerous earthquakes can be, and how much time a person takes to protect himself.

#### 3.2.2 Finding the playable elements

After defining our design goals, next we had to find the playable elements in a earthquake Preparedness context. The main idea behind it is to try to convert every action and reaction existent in the real environment into something that can be transformed into gameplay elements. After some meetings with DCE we became to the conclusion that since the game targeted audience is early age students, many information previously mentioned in section 2.2 had to be simplified and other removed, some are too complex for children to retain and too many information is introduced in a low time consumed game could overwhelm the students. Although all the elements represent real world objects and situations, precision was not intended. Instead we wanted to keep the context of each object and this way achieve
the realism that the learning elements provide when converted into playable elements. With this in mind, following are the selected playable elements that cover the common procedures that every children must be informed about as well as simplified information about earthquake consequences:

**Before**

- Children must know how to build an emergency kit with some of the most basic elements to ensure survival for three days: water, canned food, radio, flashlight, batteries and a whistle.

**During**

- If in home or inside of a building residents behaviour relies on how high in the building they are. If they are in a high floor, they must stay there, protected in a safe place, avoid falling objects, and don’t rush to elevators or stairs. Otherwise, if in a the lowest floor or if having enough time to go outside to a safe open space, it is preferable than staying inside the building.
- People usually tend to have some heavy objects in high shelves or above wardrobes like books and vases, even children usually have toys, boxes and other objects in high places that can easily fall over people during the shaking causing several injuries or even death.
- It is common having some objects nailed to the wall, such as frames and wall clocks in home, however they may become loose and fall on someone during a seismic activity.
- Some objects such as windows and mirrors can break throwing glass pieces over people.
- Lighting fixtures and ceiling lamps can fall damaging people and the property.
- People should not try to leave the building during an occurrence, debris can fall over them at any time.
- Uninformed and unprepared people do some mistakes during the occurrence of the event, some run to balconies others to stairs, two objects that might many times fall by structural damage, during and after an earthquake.
- There are some places where people can easily protect themselves to get better odds of survival, like below beds or non glass made tables. When close to some of those, individuals should drop to the ground, take cover by getting under it and hold on until the shaking stops.
- Just few seconds before the earthquake strikes, people get usually ten to fifteen seconds to protect themselves.

**After**

- After an earthquake it is important to try leaving the building to the closest family meeting place.
- After a major earthquake, future aftershocks can strike putting peoples lives in danger.
• Before leaving the building is important to turn off the gas valve and the electrical switch to avoid explosions and fire.

• When leaving home is important to get the emergency kit to improve our odds of survival for at least three days. But since our survival is priority, this is not mandatory and the individuals must have in mind that, they must prioritize leave the building and just get the kit if it is close enough or in our way to the exit.

From a learning perspective, these elements give us the benefits of learning elements being planted in gameplay and the outcome advantage to players learning about a serious and realistic context by simply playing a game. In a design perspective, these playable elements help us creating the main concepts of the gameplay, which will support us developing the rules and the mechanics.

3.2.3 Implementation

Now that we have already found the playable elements and goals it is time to project the game. To do that we will make some adjustments to the playable elements and turn them into gameplay elements, while removing and adding others to create the a fun and engaging learning experience.

Controls

Our game was firstly intended to be played in computers through a web browser, without discarding the possibility of being ported to mobile devices such as tablets and smartphones. With this in mind our solution passed by restricting all of the game input for the usage of the mouse and the left click, because in case of being played in touchable devices the game would continue to be playable. Other aspects raised by using this solution: The game had to be designed in a way that in touchable devices the finger would not obstruct relevant information in the game; We couldn’t use double click because people do not feel it natural in touchable devices, instead we limited all the interactions to single clicks and drags and drops.

Interface

An interface design relays mainly in the way of how and who will interact with it, in this case the controls of our game and the target audience for it are fundamental points to take in consideration when projecting a solution.

Because our target audience is elementary school students, we decided to create a simple and familiar interface. To do that we decided to study the way how smartphone game interfaces with cartoon styles are designed and we found a pattern. Most games follow the same main menu style as angry birds, a big play button in the center and the less relevant buttons in the corners, such as options and facebook button.
To pause the game in any screen, we considered the best approach placing the pause button at the upper right corner of the screen, and clicking there, the player can leave the game, view the controls or turn on/off the volume. We decided to include just these options in order to keep it simple, just with the most useful settings that might change during the gameplay. The position of the button was considered the same way as the previous buttons: they are visible but not in a way that interfere with what is important, in this case the gameplay.

Though the main menu and before starting the game, we can access the settings menu, where the player can turn on/off the sound, change the language, view the controllers and the credits. Even if some of this options are available when the game is paused, there are options such as language and credits that do not make sense during the gameplay session. The game language must be consistent during the whole gameplay session, so if the player want to change the game, he must do it at the beginning. On the other hand, credits as is a common practice, is placed in settings and at the end of the game.

**Multi language**

Because *Treme-treme* was intended to be a multi language game, and our target audience was early age students we considered to avoid the usage of much text and use images instead. This approach brought some advantages, being simpler to translate to other languages and making all the information easier for children to read and memorize. In addition, to keep the interface easy to understand we avoid the usage of text in the buttons and decided to use a symbolic presentation instead that goes into users mental model, and it does not require any change while applied to other language.

The Game Manager is responsible for controlling all the levels in the game and responsible for decide when a message is supposed to be shown. When the Game Manager need to display a message on the screen he calls the message through the Message Manager. This class is responsible for displaying the messages regardless the screen size and at the beginning of the game it is responsible for loading the text needed to the language in use. If the player choose to change the language the game manager asks the Message Manager to setup all again. The XML Languages is where all the text is stored and where XML Reader will get it and set it in a way that the Message Manager can present.

The first languages intended for the game was Portuguese, English and Italian and should be extensible to support any number of it. To achieve that we decided to store all the text in the game in a xml file where we just query the node that we desire at each moment. For example, at the beginning of the game, the game search for the node corresponding to the current language of the game and then search in his sons by the element that have the text that he need to show at each moment.

**Information**

As we previously mentioned, the initial idea was informing students using as fewer text as possible, not just to reduce the effort of translating information but because people can get bored or impatient reading it. It is known that people learn more by trying than by been explained how to do it, however because
some textual information was requested by DCE to cover facts about seismic activity and to give a more clear feedback during the game we had to use it.

Our solution to solve this problem and attract users attention passed by showing just the necessary information through text and using it along side with images that exemplify what is written. But to avoid being a boring screen, we decided to make the text and images behave like if they were floating.

At the beginning we had the text a little rotated to make the information not standard to call players attention, but after testing in the schools some teachers informed us that some children had dyslexia and difficult reading, and then we removed that rotation and the strength of the animation, to a way smoother but still not a static boring information. The result was a balance intended, textual information that players want to read instead of skipping.

**Art style**

Because the target audience of our game is children we wanted to transmit the information simply and call their attention. To do that we believed that an art style based on children’s illustrations and children’s books, was a suitable choice being able to present in a simple way almost any context, and it is an aspect that they are used to. The same way using a 2D presentation of the environment help us remove all the irrelevant information and present just what is important.

To be clear and easy to children understand, one of the main ideas related with the art style was
the usage of objects that goes into players mental model and make them colourful in a way that not just make contrast with the background but are fast recognizable and distinguishable from the rest.

Other challenge to this solution was show that some objects were interactable. To solve this problem we implement a glow effect in each interactable object in order to show that these objects were different from the rest.

Because the game was a 2D presentation of a 3D house, the player could find difficult know where in space the character was. To solve this we simply implemented a shadow to the character, this way the player could easily say where the player was in the space.

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.

Level 1

We needed to teach children how to build an emergency kit, and as we said before in this document, the natural way of learning is by trial error, this means doing it several times until get it right, what seemed to us the better choice to apply in this level.

In the real world to build an emergency kit people usually have a list of useful objects. However we want to remember children the importance of building an emergency kit and to be prepared. To do that, we together with DCE decided that teaching about simple but most extremely useful objects, remembers the importance of building a kit and give some insight about its most important objects.

In this level our approach to manipulate the game environment started by two options clicking in the object and it automatically moves to the kit or dragging it. At the end, even if both were suitable approaches, we decided to drag the objects instead because we believe it is the solution that gives a more natural feeling of building an emergency kit. If we had choose clicking instead, the objects would have been "teleported".

The kit was designed in a bit unrealistic form, divided in clearly six parts, however that was the solution found to make the player know that the kit was full and there were no objects overlapping.
To make players understand what they did wrong we use some common techniques of showing the wrong object red the symbolic color to wrong or bad and the change of size. This two techniques are used to take the player attention. The human eye is sensitive to color changes and the human brain because our culture associates red to bad or wrong as well as white to good and black to evil. The size smoothly changing calls user attention because our brain in most cases don’t expects that its form changes and that calls its attention.

The dragObjects is a class responsible for controlling the interaction with the game: which button is used to drag, which object is being dragged and dont let the player drag objects outside the game area. The Object script have information about it is a useful object or not as well as the previous possition before being dragged. this is very usefull to switch possition with other object. if we whanto to put an object in the same position where there are another object already there that object will move to the store position of the object being dragged.

Kit script is a class responsible for making the emergency kit scalable to hold any number of objects. this class help objects inside get it the right possitions, because the player not always let them on where they should be. The class is responsible to display feedback diferent from the textual one. when the player het something wrong the Kit script make the kit shake and show which object was wrong.

Kit interface is a class responsible for thisplaying the builton in this level and veryfy if when click on the Ok button there are conditions to win and move to the next level.
Level 2

To make the illusion of an earthquake, instead of making everything in the world shake, what is more computationally expensive and give us less control over the outcome, we decided that the best way of doing the same effect with less computational power and more control is by shaking the camera. To make it more credible we make the objects balance or move randomly just like as the earthquake was actually happening, and use a tremor background sound to reinforce that believe.

One of the main challenges related to character control was making it change floors. Since all the game was so far concluded just by the mouse click it seemed simpler to continue with that and simply click to where the player wants the character to go even if to other floor.

To evidentiate that the table and the bed are secure we decided that each of these objects would not move during the shaking. This is obviously not a realistic approach but is a good one to make the player feel secure during the quake.

To represent each division of a house we simply choose some representative objects that together make the player believe which division is. For example using a bed a wardrobe and some toys became clear that division is the child’s room.

This solution had some challenges related to the camera. We wanted to make clear the environment where the character was and where to go. We wanted the game focused on players behaviour during the game and at the same time show the house dimensions, so the player could know to where to go. To solve that we decided to divide the camera behaviour in 3 states: (i) The game starts with the camera showing the overall environment of the house and slowly zooming in and moving to change its focus from the house to the player, (ii) the camera follows the player and (iii) when the player is protected under a table or a bad the camera makes zoom out and became focused in the house instead on the player, and as soon as the quake stops the camera cames to state one and then two.

To implement the shaking we used the following Algoritm. First we start with four main parameters: `timeToShakeDecay`, `timeToShake`, `shakeIntensity` and `timeLeft`. The `timeToShakeDecay` is the time that the player have to hide before the earthquake strick. `TimeToShake` represent how long the earthquake will stand. The `shakeIntendisty` is a value responsible for how much strong the camera shake will be. At last `Timeleft`, a countdown to the earthquake.

In home and before any earthquake, the game starts doing the count down:

\[ timeLeft = timeToShakeDecay - Time\ since\ the\ game\ starter \]

The shaking intensity gets weaker with time and when reaches zero the earthquake stops:

\[ shakeIntensity = shakeIntensity - shakeDecay; \]

The camera shake in all directions but always coming back to its originalposition:
Because the game is in 2D, the player could easily put the character in front of the valve or switch and hide it without knowing what to do. Our solution passed by using two approaches: First, because it does not make any sense in a 2d world to put the valve in front of the character we decided to inform that the player is close to it with a speech balloon just like in comic books but with no text, using an iconic presentation of the switch or the valve. In addition, to reinforce the call for attention, we decided to use the same techniques used while building the kit. Here we did the same when the player is close to the valve or switch, they change its size and vary its color to green overtime, calling players attention to click on the object.

### 3.2.4 Designing the gameplay

After analysing the previous playable elements and the relation between them, we found some main concepts that will be the base of our game: **Emergency kit, Before, During** and **After** the earthquake, **Dangerous and safe places** and **Common procedures**. Following we are going to describe how each concept contributes to gameplay:

**Emergency Kit**

Building the emergency kit is the first Trene-treme’s level. In this level (Figure 3.4) 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 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.

![Figure 3.4: First Treme-treme's level: Build an emergency kit level. In this image we can see all the important objects inside the kit while the less important ones are not picked and are outside the kit.](image)

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, a video game portable 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.

This level, displays information in four distinct situations: At the beginning of the game information is displayed to inform what to do. If the player for some reason selected one or more wrong objects 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 this level ends and the player moves to the next one.

![Flowchart](image-url)

Figure 3.5: 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.

Since the first meeting with DCE, one of the main topics was which and how many objects children should be taught through our game. Because they had already experience doing activities with children in schools, they came up with the idea of six fundamental objects easy to memorise and useful enough to motivate and get the main ideal of having an emergency kit.
Other main question raised in these meetings was the usage of smartphones as a substitute of some kit elements such as portable radio and a flashlight. We conclude that even if the world changed and have some most practical ways of doing the common practices, the old fashion way is still mandatory for many reasons: Not all people have alternatives to the common procedures such as smartphones, phone batteries run out fast and if the device gets damage the user loses several functionalities. On the other hand if the user runs out of batteries from the flashlight of the portable radio he can easily change for new batteries.

Regardless all that, if people want to use a smartphone or other device as a substitute of some objects to bring on the emergency kit, they must know which ones to substitute and understand the meaning of having them. For this reason, regardless if using the conventional way or smartphones, our game displays a metaphorical representation of each object, using them virtually or as a real world object is up to the user.

**Before, During and After an earthquake**

Treme-treme’s second level (Figure 3.1) 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 overcame 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 safest 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 behaviour, 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 behaviour becomes correct. To control the character the player has just to use the mouse and 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 possibly. 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 this 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 least two aftershocks other wise the house will collapse and the player will die.

The following diagram (Figure 3.6) shows how the second level works, and which decisions must be made and avoided in order to be successful in the game.

![Diagram](image)

**Figure 3.6: Overall structure of the second level**
Aftershocks will repeat this three phase process again. However objects that have already triggered their behaviour will not do it again: an object that has already fallen will not fall again, a broken object will not became more broken and turned off switches and valves will not turn on again.

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 behaviour of objects inside. After the earthquake the zoom comes back to normal and the camera becomes again focuses in following the player.

**Safe and dangerous places**

During and after a seismic occurrence the place where we are is probably our worst enemy. In the second level the player plays inside a house full of objects, each one with a specific behaviour before, during and after the earthquake. There are some objects which we can interact with to get protection or deactivate something dangerous, and there are other objects whose behaviour is triggered randomly or when the player is too close to it, killing him most of the time if he is not protected. The three different types of object behaviour present in this level are as follow:

**Random** - Since an earthquake occurrence is by itself a random event with unpredictable consequences, during a seismic activity some objects might fall or break randomly. This object behaviours are the most common in this level, although no object act completely random, instead they have a small change to start their behaviour and that change becomes 100% when the player gets too close to them. The ceiling lamp for example can fall randomly during the seismic activity, but if the player passes under it, the object will fall and kill him as a punishment for the wrong behaviour.

**Triggered** - This objects have no random behaviour and just act in specific phases or when the player gets too close to them. During the shaking when the player is unprotected and is close to some shelves or wardrobes they will fall, killing him and after the earthquake, the house environment partially changes and two new challenges emerge gas leak and loose electrical wires.

**Interactive** - These objects don’t move and have just one clear behaviour. Before and during the event beds and tables serve to protect the player against all damages, and after it the player must interact with the gas valve and electrical switch to leave the house and win the game. To interact with the object the player just has to be close to the object and click it.

As we can see in the table 3.2.4, before the earthquake the most objects do not present any behaviour, the player just can get protection or get the emergency kit. Is during the seismic activity that the most objects can fall or break and is after is occurrence the moment where the player must leave home.
Table 3.1: List of the main objects present in this level, their type of behaviour and what they might do before, during and after the earthquake.

<table>
<thead>
<tr>
<th>Objects</th>
<th>Type</th>
<th>Before</th>
<th>During</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling</td>
<td>Random</td>
<td>None</td>
<td>Collapse</td>
<td>None</td>
</tr>
<tr>
<td>Ceiling lamps</td>
<td>Random</td>
<td>None</td>
<td>Fall</td>
<td>None</td>
</tr>
<tr>
<td>Frames</td>
<td>Random</td>
<td>None</td>
<td>Fall</td>
<td>None</td>
</tr>
<tr>
<td>Balcony</td>
<td>Random</td>
<td>None</td>
<td>Fall</td>
<td>Fall</td>
</tr>
<tr>
<td>Windows</td>
<td>Random</td>
<td>None</td>
<td>Break</td>
<td>None</td>
</tr>
<tr>
<td>Mirror</td>
<td>Random</td>
<td>None</td>
<td>Fall and</td>
<td>None</td>
</tr>
<tr>
<td>Objects hanged on</td>
<td>Random</td>
<td>None</td>
<td>Fall</td>
<td>None</td>
</tr>
<tr>
<td>wall</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kit</td>
<td>Triggered</td>
<td>Get it</td>
<td>Get it</td>
<td>Get it</td>
</tr>
<tr>
<td>Shelves</td>
<td>Triggered</td>
<td>None</td>
<td>Fall</td>
<td>None</td>
</tr>
<tr>
<td>Wardrobes</td>
<td>Triggered</td>
<td>None</td>
<td>Fall</td>
<td>None</td>
</tr>
<tr>
<td>Gas leak</td>
<td>Triggered</td>
<td>None</td>
<td>None</td>
<td>Intoxicate</td>
</tr>
<tr>
<td>Electrical wires</td>
<td>Triggered</td>
<td>None</td>
<td>None</td>
<td>Electrocute</td>
</tr>
<tr>
<td>Gas valve</td>
<td>Interactive</td>
<td>None</td>
<td>None</td>
<td>Gas turned off</td>
</tr>
<tr>
<td>Electrical Switches</td>
<td>Interactive</td>
<td>None</td>
<td>None</td>
<td>Elec. Turned off</td>
</tr>
<tr>
<td>Bed</td>
<td>Interactive</td>
<td>Immunity</td>
<td>Immunity</td>
<td>None</td>
</tr>
<tr>
<td>Table</td>
<td>Interactive</td>
<td>Immunity</td>
<td>Immunity</td>
<td>None</td>
</tr>
</tbody>
</table>

and turn off the gas and the electricity. Moreover, after the occurrence if the balcony has not randomly fallen during the shaking and the player gets there the balcony will fall killing the player.

**Common practices and procedures**

The game displays common practices and procedures through messages with images in three different ways. Some are presented before each level to inform players about real world facts and to give an overall understanding about what to do in the game. The other messages are displayed during the game to advise the player about the best practices to do in each situation and after his death, explaining what was done wrong. Based on the objectives, playable elements and meetings with DCE we came up to a huge set of small but precise messages to be applied in each case.

### 3.3 Third level conceptualization

#### 3.3.1 Third level Overview

After Treme-treme's completion, DCE decided to lead the game even further to cover other realities of a seismic occurrence: Survive a tsunami and find shelter in three days. Since we are going to continue on this project we decided to a bit more and conceptualize the solution to this new phase.

In this level, the player starts in a beach and sees the sea water rushing away from the shore, he warns everyone around and run way from the beach. The main goal of this level is to find shelter and to do that the player has to overcome several obstacles, each one to be beat by a specific object and behaviour. First he has to face a tsunami, then a flood, hunger, learn how to see at night and how to get away from a situation where he is trapped under debris.
Is expected that after complete this level, the players had gained knowledge about how to behave in each situation as well as understanding the importance of each object in his emergency kit.

3.3.2 Goals

To the second part of this game and with the help of DCE we were able to define a set of goals based on the messages intended to be transmitted in the next level. These goals gave us clear game objectives, to be implemented in our gameplay and in our evaluation. In the next level the learner must:

1. Understand why each object in the emergency kit is important and know in which situation each of them should be used;

2. Know that if close to the sea or a river after an earthquake a tsunami is likely to appear. The learner should be familiar with the common procedures to avoid a tsunami and improve his odds of survival;

3. Learn how to survive for 3 days after the event;

4. Know how to face a situation where he is trapped by debris;

5. Know that many times after an earthquake, it is not safe to return to our home and instead we need to find shelter.

3.3.3 Finding the playable elements

After defining the goals for our next level, the next step was to find what was “playable” when outside after the occurrence. The principal idea was to convert common procedures applied in the real event into gameplay elements. As well as to the previous playable elements, realistic 3D environment with exact behaviour is not intended, instead we want to achieve the same contextual correctness keeping all the realism of each real world element used for learning and converted in playable element.

To better understand the context of a tsunami and the three day survival situation, and in order to extract elements can could be converted in playable elements there was meetings with DCE where such information was made clear. After and based on that we were able to specify the following elements:

- After an earthquake a tsunami might happen, breaking or lapping up the water boundaries and getting into side walks and roads. To avoid the destructive wave, people should face way from the sea and rivers and move to high places far away from them.

- After the first destructive wave it is possible that others come to happen with variable sizes and separated from each other in irregular intervals of time, and even in situations where the waves are not very high, they are extremely lethal, because of their strong and complex currents and large amount of debris.

- In many cases people get trapped under debris. In this case they should not move otherwise the remaining debris might collapse or dust might rise and difficult the breathing.
• If under debris, people should avoid shouting for help and do that only as a last resource or when they are sure that they are going to be listened they must use a whistle in order for the rescuers to find their location.

• After the seismic occurrence it is expected that some footways and roads be blocked and some infrastructures such as bridges and buildings be damaged in risk of collapsing.

• In many situations due to some buildings bad conditions and the threat of aftershocks people might have to move to the nearest shelter to find help, and return home only when authorities say it is safe. However sometimes finding shelter is not an easy task and can take several days, reason why people should bring some canned food and enough bottled water for three days in their emergency kits.

• After an earthquake, individuals must watch out for fallen power lines or broken gas lines, and stay away from damaged areas.

• In big cities or in areas full of buildings sometimes it is difficult to stay away from them. In this situation people must take special attention and quickly face away from the olden and isolated ones 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.

• After an earthquake and before leaving home if it is possible to bring the emergency kit without putting their lives in danger they should do it, to improve their odds of survival, otherwise they should not go back inside to get it or spend valuable time searching for it.

• An earthquake might happen at any time, day or night, leading to a blackout and in order to avoid dangers and to know where to go, a flashlight should be used when daylight is no sufficient.

• A tsunami may lead many times to a flood situation, where people might easily get stuck or trapped. In this case a whistle should be used, and if trapped during night time, use it along with a flashlight to send intermittent signals.

• A portable radio is our main source of information after a seismic occurrence and can run out of batteries very fast, the same way flashlights with intensive use can run out of batteries in no time letting individuals in a troubling situation. For this reason it is highly recommended to bring extra batteries in our emergency kit and change them when necessary.

3.3.4 Designing the gameplay

This level put the player facing some of the outdoors dangers that happen after an earthquake occurrence. The player has to find shelter in three days and to do that he has to overcome several obstacles doing the right decisions and use properly the objects inside his emergency kit.
After some meetings with DCE came up the idea that Treme-treme should teach children how to survive for the next three days after the earthquake using the emergency kit previously built in the first level. Based on that we decided to conceptualize this level dividing it in three days each day with three phases: morning, afternoon and night, each one with its own challenge.

The main challenges are: Tsunami, Flood, Trapped under debris, Flashlight batteries run out and Hunger. They are sequential by this order, this means that the player must overcome one in order to move to the next one. In each challenge, the player has to think about what to do and which object to use in a limited amount of time. If after that he has yet not chosen the correct object or done the common procedure he is punished and has to do that challenge again, otherwise, he moves to the next challenge. Next we describe each challenge, how to overcome it and the expected learning outcome:

Tsunami - In the first challenge, the player is in a beach when a tsunami is approaching. He has to run far away from there and find a high place to avoid the tsunami. While running he sees an emergency kit and get it because it will be important to survive the following days.

The main goal in this challenge is to avoid the tsunami and to do that the player has to use the portable radio in his emergency kit and pay attention to the given instructions and act accordingly. There are several paths and the player has limited time to decide which path to choose. The radio starts by giving directions so the player can find the closest mountain and guidance about what to do next, it’s up to players to interpret the information and behave according to it.

With this challenge the learner must understand that after an earthquake a tsunami might happen, and if close to the sea or a river, to avoid the strong waves, he has to move to a high place and use a portable radio to know what to do and where to go in each situation.

Flood - After avoiding the tsunami the player gets trapped by water and has to call for help. While trapped he sees other people trapped and some boats saving them. To successfully overcome this challenge the player has just to use the whistle when he sees a boat, after that it comes close and gets the player to a safer place where he can continue his journey.

Trapped - In the second day the player falls in a hole and gets trapped under debris where he cannot get out without any help. To overcome this challenge he has to use the whistle again, however as before the whistle just worked when there was a boat nearby, here the player has to pay attention and listen if there are someone nearby to give some assistance and put it on the right track.

We expect that after accomplish this challenge the player has learned that if trapped he must pay close attention to his surroundings and just when necessary, put some effort using a whistle.

Flashlight batteries Runs out - At the second night, after the intensive use of the flashlight in the night before, it runs out of batteries and the player has to change them for new ones in the kit. If the player do not have the flash light on he cannot see where to go neither the surrounding dangers. So if for a few seconds he has not changed the batteries he falls and dies and has to do this challenge again.
Table 3.2: This table shows the overall set of events in the third level as well as when they are going to happen.

<table>
<thead>
<tr>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning</td>
<td>Tsunami</td>
<td>Hunger</td>
</tr>
<tr>
<td>Afternoon</td>
<td>Flood</td>
<td>Fall</td>
</tr>
<tr>
<td>Night</td>
<td>Has to use the flashlight</td>
<td>Run out of batteries</td>
</tr>
</tbody>
</table>

This challenge was introduced in this level to teach students why is important to bring extra batteries in the emergency kit and give the experience of staying at night alone without much visibility.

Hunger - With time the character gets hungry and as more hungry he gets slower he becomes, and if he gets too slow its reaction time might not be enough to avoid hazards. This challenge consists in deciding when is the best opportunity to eat and drink the canned food and the bottled water that is inside the kit, to recover the original movement speed.

This challenge is different from the others, it is not sequential but parallel to the other challenges and is up to the player to find out the best opportunity to eat and drink.

With this challenge the player might understand why it is important bring canned food and bottled water inside the emergency kit as well as learning the importance of balancing its consume.

The Table 3.2 presents each major challenge to be overcome as well as when each one happen. As we can see the game is not three day long because the player finds shelter in the afternoon at the third day. To move from one phase of the day to the next the player just has to overcome the challenge relative to that phase, for example, if the player successfully overcomes the flood challenge and is afternoon the night will fall and a new challenge appear in this case a flashlight usage.

### 3.3.5 Interface and controls

In this level the game controls are the same as in the levels before, however now new assets were added to the interface: A bag, the active object(if any selected), a hungry bar and a day counter, as we can see in the Figure 3.7.

Following we describe each element from the interface:

**Bag** - The player clicks in the bag icon and a bag with the six objects placed in level one is displayed. The player choose with object he want to use selecting it. after that the bag automatically close. The player can just have one object selected at time, this serve to the player take all attention in each object at time and understand the value of each object.

**Canned food and bottled water** - These are consumable items, this means that the player can just use it once. After selecting one of those the hungry bar gets partially filled.

**Flashlight** - Used to get better visibility. The player must use it at night to see the dangers and to where he is going.
Radio - The radio gives instructions about what to do and where to go. The information is displayed in text messages with images in no particular order, and the player has to find out which one are useful for him at each specific situation.

Extra batteries - In this level flashlight runs out of batteries at the second night and the player has to change them. To do that he just has to have the flashlight active, open the emergency kit and select the batteries. This is a consumable item so after changing the batteries once the player gets no more batteries inside the kit.

Whistle - Every time the player gets stuck he must use the whistle at the appropriate time in order to receive help from nearby people.

Active object - The active object is the object from the emergency kit selected at that time and that is being used. Consumable items are just displayed as active object for three seconds, after that the player can choose other object.

Hungry bar - This displays how hungry the character is. The hungry bar starts at 100% filled and that value decreases with time. The less bar is filled the more hungry the player gets, and as more hungry he gets more slow he becomes. If the player is too hungry his reaction time will not be enough to avoid some dangerous. For this reason is very importance to eat and balance when to do it.

Day counter - The day counter is the way that our game has to show the progression in the game. The player can easily see if he is at the morning, afternoon or night through the background and how many days have passed since the tsunami.

3.3.6 Random Events

In addition to challenges previously mentioned, in this level, there are some random events such as collapsing buildings and powerlines, and street lamps falling. The player has to pay attention to this events and if he is too hungry he might not be able to give a fast response and die. If it happens he has to start the level again from that phase.
Chapter 4

Evaluation

This chapter describes how Treme-treme was tested and if our solution was able to achieve the objective meant in this thesis. We conducted two tests each one in different schools. We start by describing the preliminary tests, explaining its purpose and which changes they brought. Then we describe Treme-treme’s final evaluation, where we discuss the objectives, procedures, test conditions, the structure of the methods used and the results of the evaluation. Finally, we present some concluding remarks.

4.1 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 fist contact we were able to gather valuable information to improve player’s overall learning experience through Treme-treme.

After analysing all the information collected from this first contact we were able to do some corrections and adjustments to improve the overall game’s experience:

- The gas valve, the electrical switch and emergency kit in the second level are now notable that are interactable;
- The zoom out and the camera position when the player is protected was adjusted to better cover the overall game environment;
- The doors and the wardrobe were redesigned to be more noticeable;
• In the family meeting place now the character finds his parents;

• The messages were too fast so we changed the speed and now they display information a bit longer;

• Some problems putting objects inside the emergency kit were solved;

• Errors related to the character control were solve;

• Some people had problems about controls. Now more detailed information is display before each level;

• A shadow was added to the character so the player could see now better were the character was in the space;

• The game difficulty had to be balanced and the same for all players. In the second level the character is spawned in any place at home and that made that people could be spawned closed to the exit door. Pedagogically speaking there is no problem because if an earthquake strikes and we are close to the exit we should leave the house instead of find protection inside. However that makes the game unfair and the players that had that opportunity would have major advantage and would not face the three phases that the game has to offer. For this reason we decided that the character can just spawn in high floors to make sure that the player can leave the house and has to pass through the three phases.

4.2 Evaluating Treme-treme

As we previously said in the section 2.1.1 it is very difficult to evaluate serious games and prove its effectiveness as teaching tools. It is hard to prove that video games are able to transmit effectively knowledge that can be used in real world situations just by playing it. For this reason, Treme-trem's evaluation followed the ideas of the research in this area, checking game's effectiveness through comparison of the obtained results and game goals.

4.2.1 The objective

The Treme-treme's development was an opportunity to validate our hypothesis described previously in the introduction of this document.

..."Treme-treme", a video game whose purpose is to inform early aged students about common practices and procedures, and promote discussion among students in class and diffuse knowledge to their families. After playing the game it is expected that the players stay aware of the objectives...

This made our evaluation’s main objective, test if people can learn earthquake preparedness through video games most precisely if after playing the game, players understanding passively change with the experience.
4.2.2 The Structure

To verify if our evaluation objectives were achieved, we used two surveys, which participants answer before and after playing the game. Using this approach, we could check if participants knowledge has changed by playing the game, and use questions related to the overall experience to verify which points are worth to develop in future.

The chosen way to identify if the players learned just by playing *Treme-treme* is quite simple: gather information about what they know before the gameplay session, and do the same questions after it and compare the values. However, this approach could not be applied in all cases. Some questions had to be made just after the experience or the game play would be affected. Others, such as register players reactions were done through observation.

In addition to the surveys, we also recorded in a database, actions in the game such as, how many times the game was played, how many times they failed building the emergency kit and died, before, during and after the earthquake, etc, in order to further help us evaluating the gameplay performance.

4.2.3 Procedure

The test took place in an elementary school and involved eighty fourth grade students that took part on this test under supervision of their teachers. Due to the fact that we had an significant number of participants, a very limited number of computers and just two hours to perform the tests, we prepared the procedures considering that: we had to divide the eighty students into six groups each group using the computers for twenty minutes. For each group we made the same one minute introduction, they made the initial survey in 2 minutes, played a game with time limited of 14 minutes and did the other survey with the time left. At the end of each group, we thank them for their help, they left the computers and we prepared the surveys and the game for the next group.

When each group entered in the room each player seated in front of a computer with the first survey ready to be answered. The surveys were very simple for children to understand and written in Portuguese because the game was only tested with Portuguese children. The first survey starts asking general questions to find out if they are our target audience. After that we did some simple questions about earthquake preparedness to evaluate their knowledge before the play season. First survey answered we guide players informing them how to open the game and start the experience. When the time was over or the player successfully ended the game they started to respond the second survey.

**First Survey** - The first survey starts by asking if the player is a boy or a girl, if use to play video games and if yes where. After that asks which places are the most dangerous and with ones are the safest during a seismic activity. This questions let us verify if they are our target audience and evaluate their knowledge before playing *Treme-treme*. 
<table>
<thead>
<tr>
<th>Number of tries</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 or more</td>
<td>35%</td>
</tr>
<tr>
<td>2</td>
<td>45%</td>
</tr>
<tr>
<td>1</td>
<td>15%</td>
</tr>
<tr>
<td>0</td>
<td>5%</td>
</tr>
</tbody>
</table>

Table 4.1: This table shows the percentage of tries building the kit.

Second Survey - To evaluate the gameplay experience this survey asks about game difficulty, controls and information displayed. A question is made to evaluate players understanding about building an emergency kit. After that the same questions about dangerous and safe places are asked and the survey ends by asking if the player could conclude the game, if he would talk about this game to someone and at last a open question about what they have learned with this game.

4.2.4 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 were 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. Next we describe the results obtained.

The second test was made to fourth grade students, so one year older than the previous ones. There were 57.5% girls and 42.5% boys doing the testes. Most of the players were our target audience: 91.25% used to play video games and 52% do it on computers while 65.33% playing on tablets and cellphones and just 34.67% enjoyed their games in consoles.

As we said before in this document, men and women brains work differently, and that could have affected in some way the performance of one side in this test. However that was not verified, 92.5% of players completed the game, and the difference between the number of female and male participants was not meaningful. So we can conclude that this game is equally accessible to each gender.

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 4.1: This graphic displays each object available in level 1 and how many people choose each one as the one that would consider most useful. Based on 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.

The Table 4.2.4 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 4.1 and knowing that 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 should be on the kit.

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

Figures 4.2 and 4.3 present participants understanding about dangerous and safe places before and after taking the test.

The good results before the gameplay session shown 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 with 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.

Some answers to the question 9 are listed below and because the tests were done to Portuguese students they had to be translated.

"The things more important to me is stay calm, not panic and drop, cover and hold under a bed or table";

"Stay calm, protect myself and as soon as the earth stops shaking, move to the closest emergency meeting point or to an adult that I know or fireman";

"Hide under a bed or table always facing away from shelves, turn off the gas and the electricity so the situation doesn’t get worse, and leave the house next to find help";

"Remain calm and face away from windows, don’t move to balconies. don’t forget the bag with the things that we will need";

"First place inside the emergency kit all the objects that are important, next find a safe place to get protection, when the earth stops shaking we must turn off the gas and the electricity and leave the
Figure 4.4: Percentage of how easy the controls were considered

Figure 4.5: Game difficulty percentage of votes

house and go to where our parents are”;

Gameplay

Game controls(Figure 4.4) were 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 most plays, 26.25% shown some difficulty learning how to control the character and interact with the world.

After analysing 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.

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

Because in the first test 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 analyse (Figure 4.6) 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.

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 he 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.

Through observation in both tests, preliminary and final evaluation we had many times were the 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 an 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 an acting accordingly.

4.2.5 Concluding Remarks

In this chapter we described how our research solution was evaluated. We started by describing the preliminary testes done to improve the *Treme-treme’s* overall experience. Then we presented the main evaluation test, this was done in a school with several classes. We described our evaluation objectives to verify if the game was able to teach earthquake preparedness and if it was an effective learn tool. We described the results and how the surveys and other data were used in this evaluation and which
conditions could influence our results. Now that we gathered and analysed the results we present our final conclusions:

After analysing the results we can easily conclude that the game was successfully able of teaching early aged students about the most common practices to be taken before during and after an earthquake. After playing the game players shown a significant positive change in their overall earthquake preparedness understanding. In some cases, more than making them learn the new material, the results shown that the game was capable of making them revise their prior believes, refining their previous understanding in this matter.

We can say that Goal 1 was successfully achieved. The results show that most participants did not know how to build a basic emergency kit, situation that changed after playing the game. However, even with good results, we can see that some participants did not choose six options (there were six correct objects) or choose some wrongly.

We believe that the misinterpretation of the question or the fact that the game were not able to make some players memorise the six objects are behind the values obtained. It is most likely that because they did not use the objects in the kit they did not assign meaning to each one what make them hard to memorize. Either way, the third level will solve the assign meaning problem, making the player use each object in the kit to survive.

The results clearly shown that most participants have already an overall understanding about which places are safe and dangerous during a major seismic activity but with some mistakes. All it takes is to believe an object is safe when in reality it does not to put an individual in danger. This small mistakes might determine life or death and because of that is highly important that everyone understand without any doubts the common procedures. After analysing the results we came up we the conclusion that after playing the game, even in cases where players knew with places to avoid and which find protection that knowledge was refined and most doubts disappeared. This proves that Goal 2 was achieved, being the game able to increase the understanding even when people has some previous knowledge.

We can say that Goals 3 and 4 were achieved. After evaluating the results and looking the answers to the open questions we concluded that the vast majority part of participants were able understand the main objective of the game, its sub-objectives and the way that each one is linked to a real world event.

During the test we had the opportunity to observe the participants reaction while playing and after gather all the information we can conclude that most players found die fun at the beginning, situation that change after dies several times. We believe that this is a simple natural reaction that people have when are not doing any progression, we thought that fun animations could partially solve the problem but was not the case.

One possible problem observed was that many children after having learned one safe place to get protection, after dying and trying the level again, would choose that same place even if not the closest
one. However the results obtained shown that people got a better understanding about this places after playing the game, what let us to conclude that these behaviours in the game has not much to do with their actual knowledge.

The game was in overall mostly considered not much difficult, easy to interact with and easy to understand. However There are a small percentage of participants that found it not so easy and hard to control that can’t be ignored. Moreover, we observed cases were people considered the controls easy where through observation we found that they were having difficulties. Despite this most people was able to finish the game and to do that had to be able to fully understand the controls.

In conclusion, this results prove that playing Treme-treme has a good learning tool with pedagogical benefits to it’s players. All Goals were achieved and players understanding about earthquake preparedness context was enhanced after playing the game.
Chapter 5

Conclusions

We started this document, introducing Serious Games and describing how they are able successfully engage and teaching individuals serious contexts that goes much beyond the game play session. This games have been recently used to train individuals in several areas and most recently prepare people for a seismic activity.

Motivated by Serious games characteristics, DCE approach us with the ideal of creating a serious game whose purpose would be teach children earthquakes risks and basic earthquake preparedness in other to better prepare them to the real event. Base on this we focus on solving this problem:

...to create Treme-treme - A video game whose purpose is to inform early aged children about common practices and procedures, and promote discussion among students in class and diffuse knowledge to their families. After playing the game is expected that players stay aware of the objectives previously presented provided by DCE.

To find a solution to this problem we researched techniques used in Serious games to improve their effectiveness as learning tools and give to players a fun and engaging learning experience while learning earthquake preparedness. Further more we studied some other Serious games that cover this same topic, studding the way they were implemented: how they presented the topic, which material is covered and how the player interact with it. After that we took some valuable lessons to be considered in our implementation.

After analysing and reviewing this Serious Games we started the implementation of Treme-treme a Serious Game that teaches children earthquake preparedness, making them perform very simple but important actions over a familiar environment. The implementation passed through define the objectives based on DCE messages to be transmitted through this game. Next we found the playable elements within the earthquake preparedness context so they could be transform into gameplay elements. Then we we designed the gameplay, converting the playable elements into gameplay rules and mechanics.

In order to test Treme-treme’s effectiveness we made two tests. We begin by doing a preliminary test to test mostly the gameplay’s difficulty, interface design and observe players reactions during the
gameplay session. The final was performed in a school with 80 fourth grade students. Each students answered a survey before and other after playing the game to evaluate their prior knowledge before and after the experience and verify if there was any gain on doing it.

Analysing the results we can confirm that the techniques used in Treme-treme was useful to design the game and contributed to it’s success in teach individuals DCE goals and advertise them to seismic risk and common practices and procedures to take before, during and after an earthquake. The game was mostly considerer easy to understand, with useful information and able to make children spread the topic. Through teachers and students reactions we can conclude that the game was well accepted and might be probably used in classroom environments bringing the advantage of video games to students and teachers that need an effective way of engaging on topics that are not familiar with.

5.1 Discussion

During the whole Treme-treme’s development and evaluation there were some contradictory interesting topics that for some reason made us think about it and worth of discussion:

- Making children die horrible deaths during the game. People can argue that it is not ethical showing to children people dying die electrocuted of intoxicated by gas (even if cartoons). During the test was not observed any reaction related to how this images affect children and the test was done in few hours, would be needed several days and psychologists to evaluate any behavioural change. However we presented death in some cartoonish and comical way to avoid any inconvenient.

Even if creating a game that cover earthquake preparedness and shows positive results, many playable elements are presented unrealistically for the gameplay’s sake. For example the stairs cannot break randomly during the seismic activity, other wise the player would not leave the house, but break and fall immediately if during the seismic activity the player is in the stairs. An earthquake is an unpredictable event with random consequences. However when developing the game some unpredictability has to be restricted to create a game otherwise would be a simulation. However, it is evident that teaching the pedagogical material is more important than the veracity of the gameplay elements, so these changes are acceptable, but should be avoided. Moreover, due to the fact that the we created a 2D game full of cartoonish iconic presentations of real world objects and a real world house, During the event people have to react in a three dimensional environment and avoid three dimensional objects. Such game and simulation would require much effort and we believe that wouldn’t bring much knowledge to our target audience.

There were situations were the pedagogical material was against some gameplay elements. One example of that is the usage of score to encourage repletion and show the overall performance during the play session. However after some meeting with DCE we came up to the conclusion that wasn’t possible to attribute points to anything in the game: we couldn’t give points for being fast otherwise we would be encouraging the plays to rush and leave the house instead of finding
protection. The same to the emergency kit we could not give points for getting the emergency kit because people should prioritize their life and just get the kit if on our way to the exit. Other topic in conflict was that the game should have almost no text at all, because children get bored when face much text. However information not turned into playable elements were turned into messages rising the volume of text in our game.

5.2 Future Work

Due to the success achieved during the testes in schools and the warm acceptance by teachers and student there were opportunity in continue in this project:

- Through the results we can see that some people (minority) considered the controls not much easy to understand and the game difficult. We made instructions with images telling how to control the character and interact with the environment but for some people that does not seem enough. So there are other ways to made people understand better the controls and how interact with the environment. The solution can pass by making a video as an introduction to the game, explaining step by step how to play.

- As we can see in the results, even after play the game some players seem not remember which objects are important to have on the emergency kit. Was we said before, this must have happen because people did not assigned meaning to each object. As we are going to continue on this project we intend to solve this problem making the children use each object inside the kit to overcame challenges and this way attribute meaning to each one.

- In future as we conceptualized we are going to cover other earthquake realities: a tsunami, a flood, hunger and trapped under debris and this way make the players explore new life or death situations and teach them how to survive in each situation.

- *Treme-treme* was not able to incorporate several design techniques because much of them were against the pedagogical material. An example of that is the usage of points to improve the replayability and show the importance of each object, behaviour or the time took to complete the game. We could not do it because this way we would have been teaching children to take the impulsive behaviour of leaving the house or put their life in danger to get the kit to get more points. Nevertheless, our evaluation shown good results, and proved that the game were a effective learning tool. Future work should explore new ways to implement these techniques without conflicting with what if being taught.
Bibliography


Appendix A

Other games about earthquakes

Stop Disasters

*Stop Disasters*\(^1\) is a simulation game, from the United Nations (UN) and International Strategy for Disaster Reduction (ISDR), enables players to realize, the risks and what methods of prevention can effectively save lives and reduce the financial impact that natural hazards cause. The player can choose from 3 different difficulty levels: easy, medium or hard, and depending on the disaster the player is trying to endure, as well as his skill doing it a disaster scenario can take 10-20 minutes.

![Image from Stop Disasters](http://www.stopdisastersgame.org/en/home.html)

In this game the player can experience 5 natural disasters: earthquakes, wildfires, floods, tsunamis and hurricanes, and after selecting the desired disaster scenario few pop up windows appear to briefly explain what the player has to do. The player has the role of plan and construct a safer area for citizens to live. At the beginning of the game budget is given to the player in order to save the population from disaster. To do that the player must choose between different types of housing and effective upgrades. When all the population have been housed, a red flashing button appears and by clicking it the player has the option of starting the disaster. After the disaster a front page newspaper report appears. There, the player can choose to view the scene or the report. In the first one the player can look back at the disaster scene and its consequences, while the second report how the buildings and population were affected, how successful was the mission, and what bonuses were scored. At the end it is shown a

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\(^1\)http://www.stopdisastersgame.org/en/home.html
certificate giving a grade on how well the player did. Highest scores are kept track of and recorded in order to encourage players to play again while competing against everyone in the world.

**Save the Children Earthquake Response**

*Save the Children Earthquake Response*\(^2\) is a game developed by Enabled at the request of Save the Children. This iPhone game was designed to simulate a real world disaster relief, requiring players to identify needs and manage staff, people and resources and allocate them where they are mostly needed, and this way save most people as possible. In this multi task game players must supply water, shelter, and medical aid to victims of the disaster, while supervising different phases: get people to the right tents, direct supply trucks and prioritize people's needs. In the first one, the player must select the character and the people in need and guide them to the health clinics, water distribution tents and shelters. Resources run out fast, so the player has to get new resources and put them in the respective tent. Next, trucks start to arrive and the player must tap the correct bay to load the supplies. At last but equally important, people start to appear in an open area and the player must select the people in danger to join line for aid. Each game level has limited time, and at the end a pop up window show the score and how many people died.


**Rebuild Chile**

On 27th February 2010 Chile was hit by a huge earthquake that claimed over three hundred lives and cost between $4-7 billion of damage with reconstruction that would last for between 3-4 years. *Rebuild Chile*\(^3\) is a game developed by UNICEF whose purpose is to raise awareness of this earthquake and its consequences in that country as well as help raise funds towards the reconstruction of the affected cares of that country, and in particular, to meet the needs of Chilean children. In the game the player can donate and gain currency to be applied in the game, all funds go to Unicef Chile. This game is a very accessible puzzle. The player has to solve the current one in order to go to the next and this way progress in the game. He controls a bulldozer moving it and pushing the debris to an exit, making this

\(^3\)http://www.havefungaming.com/play-389-rebuild-chile.html
way, money to rebuild more houses in that area. If the player has enough money and is stuck, he can
call an helicopter an pay for its help. The play time of each puzzle depends on its complexity and on the
player skill.

Figure A.3: Image from Rebuild Chile.
Appendix B

Some of the messages present in the game

This list describe some of the most important messages display in *Treme-treme*. They had to be small in order to children to be able to read, and had to cover fundamental information so they could progress in game and learn about earthquakes.

- The earth strikes, protect yourself!
- Search for a safe place.
- Drop, Cover and Hold on!
- Remain in a protected place until the shaking stops.
- Now, try to leave your home.
- Go to your family’s emergency outdoor meeting place.
- Great! Take your emergency kit with you.
- Upss! Avoid places with electrical wires.
- Warning! Gas leak!
- Keep yourself away from balconies.
- Take special attention to walls condition and ceilings.
- Stay away from furniture that can fall.
- Keep away from stairs, they may fall.
- Oh, no! Face away from windows and glass.
- Oh, no! Avoid places with chandeliers and ceiling lamps.
• Face away from mirrors or windows.

• Stay away from frames, ceiling lamps and other objects that can fall over you.

• Prepare yourself for an earthquake. Make your emergency kit!

• Congratulations, you’re ready for anything! You’ve put together a very helpful emergency kit.

• This aftershock is gone. Now you must leave your home!
Appendix C

Surveys

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)