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A Serious Game: Defying Disaster Earthquake

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A serious game

Defying Disaster: Earthquake

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A Project

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Committee: Professor Robert W. Lindeman

Abstract

The tremendous growth in the serious games market presents the opportunity to help people learn through playing games. *Defying Disaster* is a 2D side scroller serious game designed to teach people how to prepare for and handle an earthquake. Players do a series of mini games that provide earthquake survival tips while interacting with a larger world after an earthquake disaster. An evaluation with thirty people compared learning disaster knowledge through reading materials versus playing games. The results show people learn better through playing *Defying Disaster* than reading materials.

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Acknowledgements

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Chapter 1: Introduction

Earthquakes strike suddenly, without warning. Earthquakes can occur at any time of the year and at any time of the day or night. On a yearly basis, 70 to 75 damaging earthquakes occur throughout the world [1]. A total of between 2.6 and 3.1 million people are estimated to die in quakes in the coming century, according to Thomas and James' study. The number of quakes with a death toll over 50,000 may climb to 25 from a total of seven in the 20th century [1]. Those numbers assume the global population will climb to 10.1 billion by the year 2100.

To some degree, earthquake survival tips can help avoid death. For example, people will have a higher probability of surviving if they know where a safe place to hide during an earthquake is. Currently, people can acquire such knowledge only through books, websites and videos.

Serious games are growing rapidly as an industry as well as a field of academic research. Figure 1-1 shows that the number of serious games in industry have increased more than 600% from 2000 to 2012. The forecast predicts the serious games market, which Ambient Insight Research calls game-based learning, will grow from $1.5 billion in 2012 to $2.3 billion in 2017 [3]. The larger simulation-based learning market is expected to grow even more from $2.3 billion in 2012 to $6.6 billion in 2017 and the learning games market from $3.9 billion to $8.9 billion in 2017.
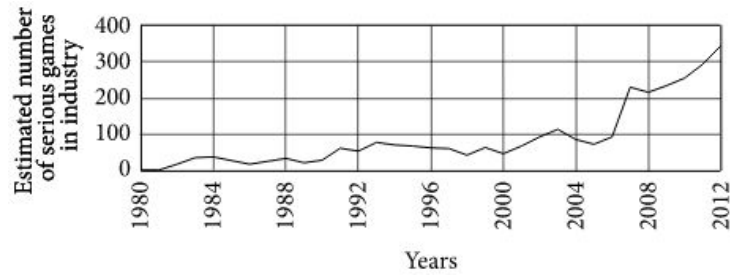
Figure 1-1: Serious games growth in industry [2]

Currently there are more than half a billion people worldwide playing computer and video games at least an hour a day -- and 183 million in the U.S. alone [4]. The younger people are, the more likely they are to be gamers -- 99% of boys under 18 and 94% of girls under 18 report playing video games regularly. The average young person accumulates 10,000 hours of gaming by the age of 21. Figure 1-2 shows that the daily time spent playing video games per capita is predicted to 28.3 minutes in 2018.
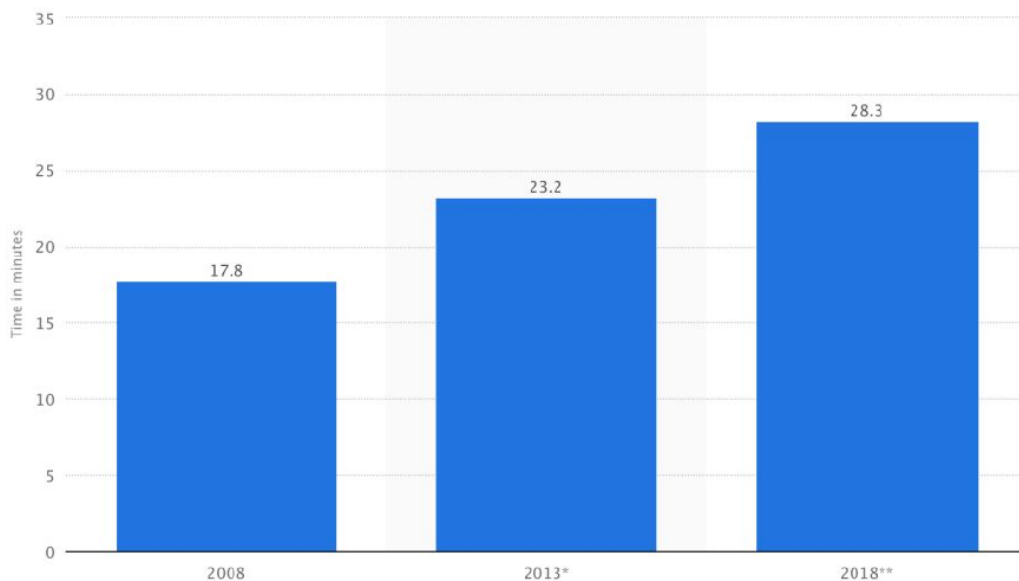
Figure 1-2: Daily time spent playing video games per capita in the United States in 2008, 2013 and (2018 predicted) (in minutes) [5]

People need earthquake survival tips to protect themselves and people use games to have fun. Is it possible that people can have both fun and gain knowledge of earthquake survival tips through playing games? Because of the positive effects of computer games on motivation, it may be possible to create a game that motivates players to learn about preparing for and surviving an earthquake. This is why we created *Defying Disaster*, a 2D side scrolling game that teaches people how to prepare before an earthquake and how to save themselves and others during such a disaster.

Chapter 2: Related Work

2.1 Earthquake Preparedness

Before we designed the game, we did research into disaster preparedness through FEMA's website [6]. There are four disasters in FEMA's website in total: earthquake, winter storm, tsunami and hurricane. Since earthquakes have the highest frequency of occurrence and cannot be predicted. We chose to focus on them as the central type of disaster in our game.

We extracted some of the elements from FEMA's suggestions [6] and applied them to our game.

Before an earthquake:

1) Build supply kits

    a) Food, at least a three-day supply of non-perishable food

    b) Battery-powered or hand crank radio and a NOAAWeather

    c) Whistle to signal for help

    d) Dust mask, to help filter contaminated air and plastic sheeting

    e) Moist towelettes, garbage bags and plastic ties for personal sanitation

    f) Wrench or pliers to turn off utilities

    g) Can opener for food (if kit contains canned food)

    h) Local maps

    i) Cell phone with chargers, inverter or solar charger

2) Check your home

    a) Fasten shelves securely to walls.

    b) Place large or heavy objects on lower shelves.

c) Store breakable items such as bottled foods, glass, and china in low, closed cabinets with latches.

d) Fasten heavy items such as pictures and mirrors securely to walls and away from beds, couches and anywhere people sit.

e) Brace overhead light fixtures and top-heavy objects.

f) Repair defective electrical wiring and leaky gas connections.

g) Secure your water heater, refrigerator, furnace and gas appliances by strapping them to the wall studs and bolting to the floor.

h) Repair any deep cracks in ceilings or foundations.

During an earthquake:

a) Put out fire by using extinguisher

b) Perform CPR only in necessary conditions

c) Locate safe spots in each room under a sturdy table or against an inside wall. Stay away from glass, windows, outside doors and walls, and anything that could fall, such as lighting fixtures or furniture.

d) Put out the specific fire by using the right tools.

2.2 Literature Review

Defying Disaster is a serious game, so it is crucial to take a deep look inside how to successfully design a serious game.

2.2.1 Serious Game Design Framework

MDA (Mechanics-Dynamics-Aesthetics) framework by LeBlanc, Hunicke and Zabek (Figure 2.2.1-1) is a formal approach used to analyze games. It formalizes the

consumption of games by separating the game into three components, mechanics, dynamics and aesthetics.

Figure 2.2.1-1: MDA framework

However, the MDA framework focuses on the design of games for entertainment. Designing serious games offers a unique set of design challenges that are not encompassed in the MDA framework. Therefore, we need another framework that focuses more on serious game design.

The DPE, (Design - Play - Experience) framework (Figure 2.2.1-2), was created as an expansion of the MDA framework to address the needs of serious game design for learning. It focuses more on the specific method of analyzing and designing a serious game for learning.

Figure 2.2.1-2: DPE framework

We used these two frameworks to do most of the research and design work during the whole development process.

2.2.2 Serious Game Analysis

We used MDA and DPE framework to analyze several serious games and reference games

Figure 2.2.2-1: *Disaster Hero* screenshot [11]

Disaster Hero (Legacy Interactive, 2010) (Figure 2.2.2-1) is a free online game that teaches families the skills needed to prepare for, survive, and recover from a natural disaster. The game addresses four main topics: basic preparedness, common disasters and their associated effects, tips for treating common injuries, and information on geographic-specific disasters. In addition to presenting useful disaster knowledge, the game emphasizes three crucial steps for preparedness – make a plan, get a kit, and be informed.

Advantages:

1. Instruction Design: The aim of the game is clear. The educational content and forms is also abundant.

2. Mechanics Design (gameplay): It consists of many different kinds of games including shooting game whose targets are some educational questions, puzzle games which need the player to find information to survive the disaster, or just games to teach how to treat injuries. Score are the reward for all the games.

3. Storytelling: The designer creates different virtual opponents of the player to visualize the disaster, like the hurricane is a girl named Tempest. In the game, players need to defeat their opponents, as same as defying a disaster. Each of the opponents has different personalities, which makes the story be more vivid.

Disadvantages:

1. Experience: The game relies on players reading a lot of text and listening to recorded information which make players feel like they are reading a book with score system instead of actually playing.

2. Gameplay: The design of the mini game is awful. There is a shooting game, once the player shoot a target correctly, a question will appear. The designer might want to make this game be accordance to characters' personalities and functions. However, the gameplay does not make any sense with the knowledge, and also make the game seem to be a stupid educational game.

3. Storytelling and gameplay: Though the design of the virtual opponent is good, players do not have a chance to replay the minigame again once they are defeated by their opponents. That makes the competition with virtual opponent meaningless.

Stop Disasters! (Playerthree and UN/ISDR, 2012) is designed to raise awareness of natural disasters' significant impact and explain simple precautions that can save lives.

Before a simulated storm, players must construct buildings with an infrastructure that can withstand damage, and strategically communicate with other in-game characters to survive. This game is a unique approach to teaching families to take an active role in home disaster

Planning.

Figure 2.2.2-2: *Stop Disaster* screenshot [12]

Advantages:

1. Experience: Cultivating players' sense of a whole protection strategy while facing the disaster by letting players build their own strategies to withstand the disaster.

2. Gameplay: The display of the educational content is more natural than the other serious games. For example, Figure 2.2.2-2,the player receives some special tips before the disaster occurs. These tips influence the strategy in game.

Figure 2.2.2-3: *Code Combat* screenshot [13]

CodeCombat (CodeCombat team, 2013) is a 2D HTML5 role-playing strategy game, whose goal is to use coding techniques to guide the player through a series of areas and levels that are made to advance in difficulty as programming skills improve. The intended outcome of *CodeCombat* is for the user to become familiar and practiced with an array of variable programming essentials.

Although *CodeCombat* seems not be about disaster preparedness, it is the first serious game that was compelling and addictive. Coding seems to be boring to learn and use, but *CodeCombat* transfers the in-game feedback to real knowledge, that we can learn and use it to design *Defying Disaster*.

Advantages:

1. Experience: The player will get feedback and rewards through the whole game, thus improving their motivation for learning. For example, when the player begins, s/he can follow the tips and hints to type simple code (Figure 2.2.2-3) and then run it to see whether or not that code completes the level goal. As the code runs, the player can see real-time feedback about how the code is affecting the avatar's actions, which also makes

debugging easier and more intuitive. In later levels, the player may need to manually operate the avatar in-game instead of just watching and waiting for the result, which improves the playing experience.

2. Design: The instructional design of this game is clear and abundant. It provides several coding languages from which the players can choose.

Disadvantages:

1. User Experience: It might improve the user experience if the design allowed the player to collect their previous code in a notebook, instead of needing to replay the older levels over and over again.

Zettai Zetsumei Toshi (Irem, 2005) is an action game for the PS2 set in 2005 . The nearby buildings are destroyed because the nearby levee breaks and the Hudson River begins to flood the city from above. Joshua and Stephanie are just two of the waiters helping make the conference go as smoothly as possible. An important goal of this game is to escape from the disaster and rescue other survivors. Because the player is an ordinary person, if the earthquake happens, s/he needs to collect enough food and water at any time in order to maintain their stamina.

Advantage:

1. Mechanism: The thirst and body temperature system significantly impact the player's actions, which allows players to experience the threat of catastrophe. (Figure 2.2.2-4 next page)

Figure 2.2.2-4: *Zettai Zetsumei Toshi* screentshot

2.2.3 Reference game analysis

After we analyzed these serious games, we came to several tips about serious game design that we can use . Then we tried to focus more on the game design itself, since we would like to make an interesting educational game instead of interactive reading material. Therefore, we searched, played and analyzed several 2D side-scrolling adventure games, aiming at making our game more interesting and attractive.

Valiant Hearts: The Great War (Ubisoft, 2014) is a puzzle adventure game about four characters in World War I who help a young German soldier reunite with his love. Each character is able to interact with objects, perform a melee attack to knock out guards or smash through debris, and aim and throw projectile objects such as bricks or grenades. There are also some traits unique to each character.

It can also be treated as a serious game, because it attempts to incorporate actual history into a fictional story through object descriptions and title cards, though it still relies on reading and the history material that can be skipped. Therefore, there are several points that we can learn from and use in our game design.

Figure 2.2.3-1: *Valiant Heart* screenshot [14]

Advantages:

1. Storytelling: It uses notes and letters, which can be found throughout the game, to tell a moving story.
2. Mechanics: Switching between characters is determined by the narrative needs of the game, not player choice. Players see the war from many different vantage points as the story dictates, allowing the designers to use different characters for different functions. Moreover, the four characters have four different functions.
3. Experience: There are a lot of items that players can pick up on the ground, and every item has its own background and historical facts. Players may also want to collect all the items in order want to get an achievement.(Figure 2.2.3-1)

Child of Light (Ubisoft, 2014) is a 2D side scrolling role-playing video game which puts players in the shoes of Aurora, a child stolen from her home, who, in her quest to return, must bring back the sun, the moon and the stars held captive by the mysterious Queen of the Night.

The game has beautiful game art and an interesting fighting system. We can learn from the puzzles (like collect glasses with different colors to complete the level) and also some interactive operations (like the operation of switch the character's status of "walk" to "pull a box").

Figure 2.2.3-2: *Child of Light* screenshot [15]

Advantages:

1. Mechanics: *The Child of Light* also has several different characters, and they have different mechanics, which make up an interesting fighting system. As for its abundant inventory system, players have lots of choices to complete the game.

2. Game Art: Uses 2D images to express 3D layout and position. Though *Child of Light* is just a 2D game, it takes advantage of different movement speeds of different layers to express different distances of the buildings. In addition, it uses the dissolve of the front layer to express the character's movement like going inside a house or getting out of a building, or a cave.(Figure 2.2.3-2)

3. Level Design: There is always a vista in the background, which will become bigger and bigger as the game progresses. Therefore, players always are reminded that they are making progress in the game.

Limbo (Playdead, Microsoft Studios, 2010) is a 2D side scroller, incorporating the physics system Box2D to govern environmental objects and the player character. The player guides an unnamed boy through dangerous environments and traps as he searches for his sister. The developer built the game's puzzles expecting the player to fail before finding the correct solution. They called the style of play "trial and death", and used gruesome imagery for the boy's deaths to steer the player from unworkable solutions.

Figure 2.2.3-3: *Limbo* screenshot [16]

Advantages:

1. With the "black and white" art style, the game provides a large imaginary space for the player.(Figure 2.2.3-3)

2. With kinds of cruel death animations make the player feels nervous during the whole game, the player will be highly concentrated on the game. It is a good thing while learning.

We planned to design some death animations in our educational game in order to let the player feel nervous while playing. What we cannot use is the art style, because our game needs a clear art style with more details that can make this educational game be more efficient.

2.2.4 *Defying Disaster* - Game Design

After analyzing a bunch of related games, we've gained some insight into serious game design. We then decided to use an expansion framework of the DPE framework, which focuses on serious game design.
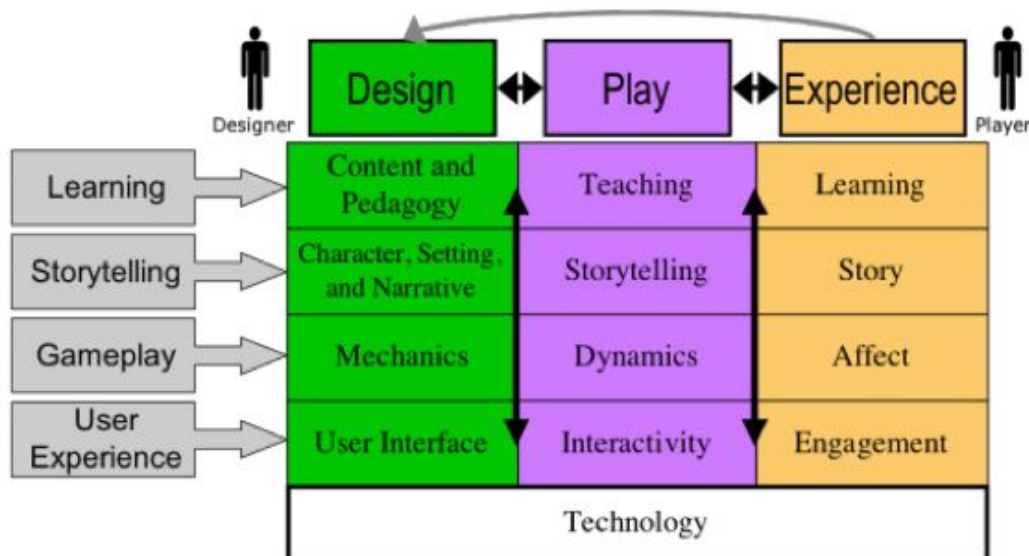
Figure 2.2.4-1: The expanded DPE framework

The expanded DPE framework (see Figure 2.2.4-1) depicts the sub components of serious game design, including the Learning, Storytelling, Gameplay, and User Experience layers. Each layer has a design, play, and experience aspect. Technology is represented in the bottom layer. While the designer does not necessarily design the technology, the design itself is realized (or not) within the technology. We first designed the game on paper.

Instructional design (Learning layer): We selected most of the knowledge points from the FEMA (Federal Emergency Management agency) official website. Meanwhile, we got in touch with people (Chad Council, chad.council@fema.dhs.gov) in FEMA to get a useful guide about earthquake preparation knowledge. For example, before we designed the CPR game, we collected reading materials about CPR. One of our team members even got the certified in CPR from the Red Cross. Therefore, we built up learning goals quickly, and then scaled down and generalized the knowledge. We finished this part at a very early stage in the design process.

Storytelling layer: After we finished most of the instructional design, we set up a background story and characters mechanics.

Level 0: Knowledge of Preparedness:
John and his daughter are living in a peaceful Fairview town near Los Anglos. However, one day, they get the alert that a large earthquake may occur soon, and begin to prepare for the disaster according to the guide. The earthquake occurs, and the town is in ruins. Though John's family prepared well in their house, they are still stuck in ruins. The army rescues John. Unfortunately, John's daughter, Lisa, was buried in the ruins and died. John was really depressed about the loss of his daughter, so he decided to be a volunteer in a disaster rescue department. Meanwhile, he adopted a dog, Buddy.

Level 1: Knowledge during the disaster:

Ten years later, history seems repeat itself and Fairview suffers from another earthquake, and John returns to his former hometown for the first time. This time, he hears a girl's breath, and then sees a girl's hand with same red bracelet as his daughter. He uses all his strength to save her from the ruins. After the girl is rescued, John finds her name is Sarah, a 19-year-old girl, who is majoring in nursing. To help with John's work, Sarah decides to join John and Buddy. They just begin to save people's lives in this earthquake.

Gameplay Layer: As for other serious games and reference games, we designed *Defying Disaster* to be a 2D side scrolling adventure puzzle game. Meanwhile, the instructional part is displayed in separate mini games, which can be replayed several times, thus improving the educational effect. For example, in CPR mini game, we wanted to come up with an idea that could help the player remember the rhythm of the CPR step. So we decided to design a rhythm musical game based on the knowledge that has been summarized in the learning layer. Once the player remembers the music, s/he will remember the rhythm. Meanwhile, real time feedback and reward is also very important, so we created a large space for an empty heart which fills up as the player succeeds.

User Experience Layer: Players can read all the information they encountered through the notebook user interface. They can also read the instruction about each item, not only the functions, but also some interesting stories. According to the framework, we want to design the user interface to be almost transparent to the users, so we did not add number or status in the game scene. All the icons and UI part can only be seen when triggered by events.

As for the influence between each layer, the framework shows that it would be better to change the upper layer design while working out design conflicts. Therefore, when we meet some conflicts between storytelling and gameplay, we always consider revising the storytelling design first. For example, we planned to design a game with a moving background story that can also connect every character and level in game, instead of a collection of minigames. However, with the limitations of time and development skills (both art and tech), we thought completing the gameplay part was more important than displaying the background story. So we decided to scale down and delete the story.

Chapter 3: The Game Design

3.1 Overview

Defying disaster is a 2D serious game that is playable on PC or Mac. The goal is to teach people how to prepare before an earthquake and how to save themselves and others during a disaster. The game has three levels. In each level, there are mini games to teach people about disaster preparedness and interactions in the game scene to increase the gameplay and teach people. The game has 3 core levels which include 5 mini games. The core levels contain a preparation level, level 1 and level 2. We use level 1 and the CPR game as examples to explain the design. See the complete design document in Appendix F.

3.2 Game mechanics

This part includes the level goal, level flow, victory condition and gameplay design. We separated the whole game into 3 levels. Each level has two or three mini games.

3.2.1 Level goal

The game goal of our game is making players know some knowledge about preparing before an earthquake, and know how to take measures against earthquake. The goal of the level 1 is less about actually preparing for an earthquake and more about teaching players the affordances in the game space. The factual information about preparing is contained in the mini-games and the later levels.

3.2.2 Level flow

Players need to solve puzzles in level 1 according to game flow. First of all, players need to find axe and shovel in the underground by controlling the dog, Buddy. Secondly, players need to use axe to break the fire-hydrant cabinet to get extinguisher. At the same

time, the characters need to turn off the valve. Third, the extinguisher can put off the fire. Then saving Sarah after digging out the ruins by shovel. The final victory condition is using Sarah to save the wounded by CPR. When the player finishes these puzzles sequentially, level 1 is over. The following figure is about the level flow.

```
                          start


                  Find the            Find the entrance
  Level 1        compass                  for the
                                        underground

                                     Get the axe and
                                         shovel
                  Turn off
                   valve              Break the glass of
                                       the fire hydrant

                                        Take the
                                       extinguisher

                            Put out a
                              fire

                            dig out
                           the ruins

   change to sarah                      Not change to sarah

                           Save Sarah

   Sarah go                            John go
   upstair                             upstair

   Use the                             Use the
   seesaw to                           seesaw to
   go across                           go across

   Find the                            Find the
   wounder and                         wounded
   start mini
   game 3(CPR)

          success   fail

   Pass the
     level
```
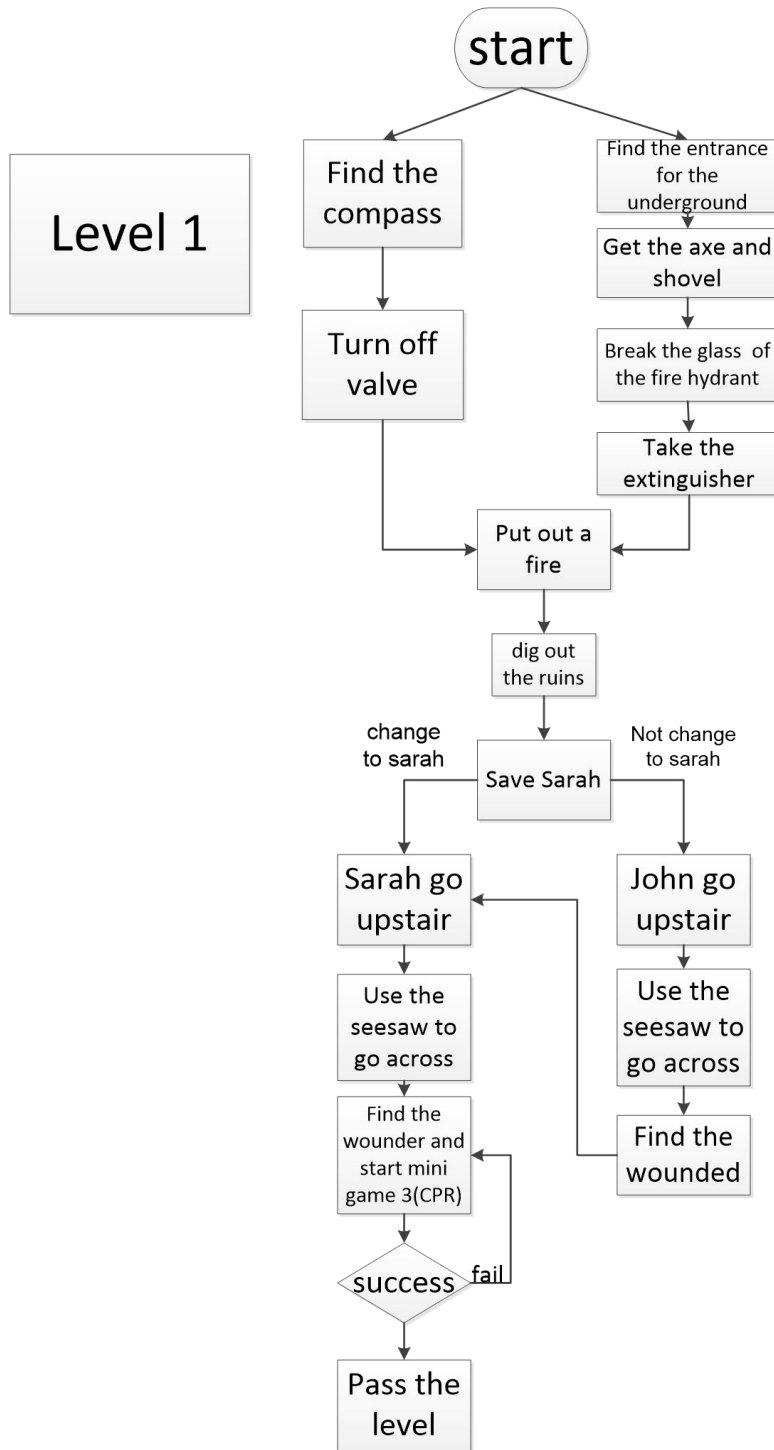
Figure 3.2.1-1: Game flow of level 1

3.2.3 Victory condition

Player needs to do three steps. The first step is to put out a fire in the first floor. The second step is to remove the ruins by using the shovel. The third step is to switch to another character, Sarah, go upstairs, and save the wounded people by passing the CPR game.

3.2.4 Gameplay design

A diary will pop out when players successfully solve each puzzle. When players solve every puzzle and pass the level, the diary will include all the knowledge points and related materials for players to read. For example, when players pick up the extinguisher, we will let players know how to use the extinguisher by using the diary. After players put out a fire, the diary will contain the four ways to put out a fire: isolation between fuel and the fire, isolation between oxygen and the fire, decreasing the temperature of the carburant, and chemical inhibition.

In the game, there is no dialog between characters. We try to use simple images to guide the player towards what to do next.

In an earthquake, fire is the most common subsequent disaster. In the first level, we designed a puzzle to teach people how to put out fires and remind them to turn off the gas valve during the process of putting out fire.

3.3 Mini Game: CPR game

This mini game can teach people about basic CPR knowledge.

3.3.1 Level goal

In order to teach the player the basics of CPR, we use the song "Staying Alive," which provides the correct number of chest compressions per minute. We use a basic rhythm

game mechanic where chest compressions come down a strip and the player must push a button when each beat comes across the line.

3.3.2 Victory condition

When the heart is filled with the blood, the player wins the mini game.

3.3.3 Game flow

At the first, the game starts and player should press the key following the music rhythm. Every time the players press the key right following the rhythm, there will be some blood filled into heart. After the heart is full of blood the player wins the game.
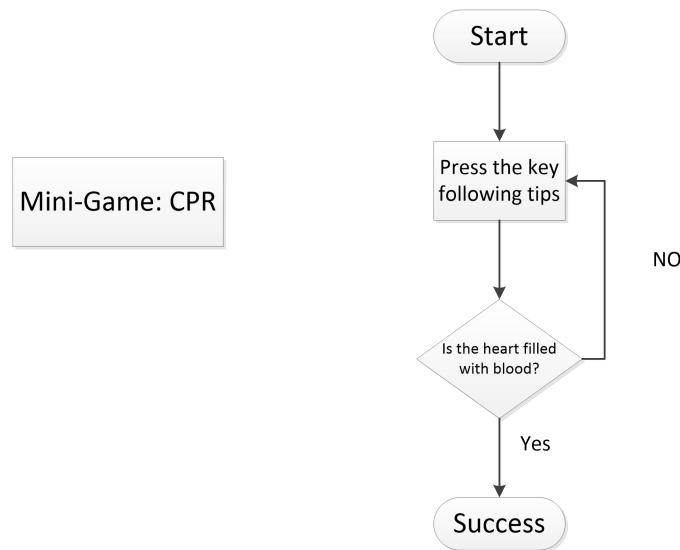
Figure 3.3.3-1: Game flow of mini game: CPR

3.3.4 Gameplay design

We made special background music for this game, the rhythm of our music is exactly as the same as the rhythm people need to remember to perform CPR. We made the music for this section of the game because it has close to 104 beats per minute, and 100-120 chest compressions per minute are recommended by the British Heart Foundation [9] and endorsed by the Resuscitation Council (UK) [10].Our music has close to 100 beats per

minute. The player has to keep up that rhythm by pressing a key in time, much like actual CPR.

There are two keys the player must press, one for compressions and one for mouth-to-mouth.

As the player succeeds, a heart on the left side of the screen slowly fills with color. When the heart is full, the player has succeeded in resuscitating the victim.

We made it clear that this mini game is no substitute for actual CPR training, and point players to where they can sign up for CPR classes in their area.

Chapter 4 Game Art

Since our game is an educational game about disaster, we decided to use a gray color scheme with a cartoonish art style in the whole game. Therefore, we searched for related reference art and pictures and create several concept art images about both the characters and the game scenes.

4.1 Graphics

4.1.1 Concept art and reference art

In the beginning, I didn't have too much experience with side scrolling game art, and I just tried to create concept art with different art styles based on a general idea of game design. I tried to find the most suitable art style for our educational serious game.

After our first proposal (see Appendix E) was done, we had a much clearer vision of the game. I searched for a bunch of reference pictures (see in the appendix D) about peaceful villages and buildings in San Francisco, and created the first version of the concept art about the game scene.

Figure 4.1.1-1: Disaster concept art

Figure 4.1.1-2: Game scene concept art

After I played *Child of Light* and *Valiant Heart*, I thought the art styles of these two games were suitable for our educational game. I picked up their character design, searched for a real fireman's outfit picture from the Internet, and finished the first version of the concept art of the game characters.

Figure 4.1.1-3: Reference character: Valiant heart (left); Child of Light (right)

Figure 4.1.1-4: Concept character design: The first group of concept characters designs

4.1.2 Game scene

The finished game art style is totally different from the concept art style, neither the impressionistic one, nor the Eastern style one. Since it is an educational game, the most suitable art style should express and transfer the knowledge efficiently. So I thought the style should not be too fancy. It should be the cartoonish style with clear details. The first concept art image (Fig 4.1.1-1) is too stylized and seems to take place in a fantasy world. The second image (Fig 4.1.1-2) is closer to the real world, but the lack of clear lines and impressionistic nature makes it feel dream-like. We wanted our game set in the real world, so opted for clear lines and hard edges, while still keeping the cartoonish style to lighten the mood.

Figure: 4.1.2-1: Game scene – camera view

Figure 4.1.2-2: Game scene: Perspective

4.1.3 Mini game

We have four mini games in these two levels. You can see one of the mini-games, the Supermarket, here. The others can be found in Appendix D.

The art style of the Mini-game is more conceptual than the art of the game scene, because I wanted to remind the player that they are playing this game in TV screen. The different art styles may remind players when they need to learn knowledge and start remembering knowledge points.

Figure 4.1.3-1: Mini game-Supermarket
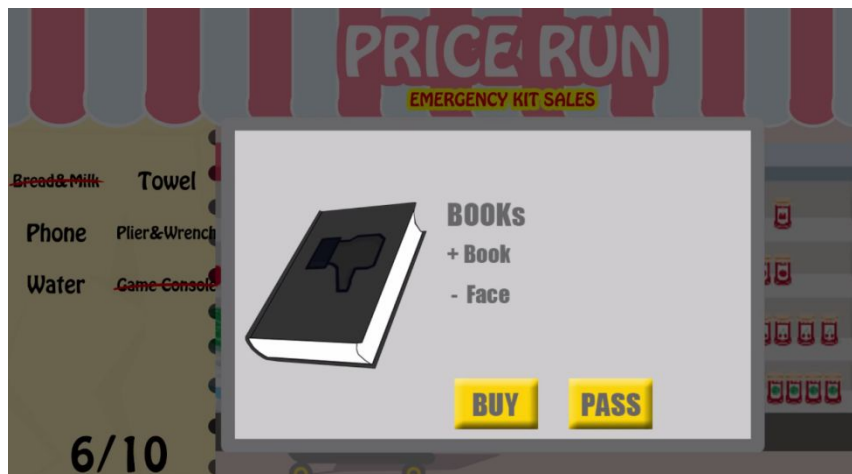
Figure 4.1.3-2: Mini game - Supermarket: gameplay (up); success scene (low)

4.1.4 User Interface

The inventory UI contains the main part of the educational text that players can review the knowledge point at any time.

Figure 4.1.4 -1: Package system
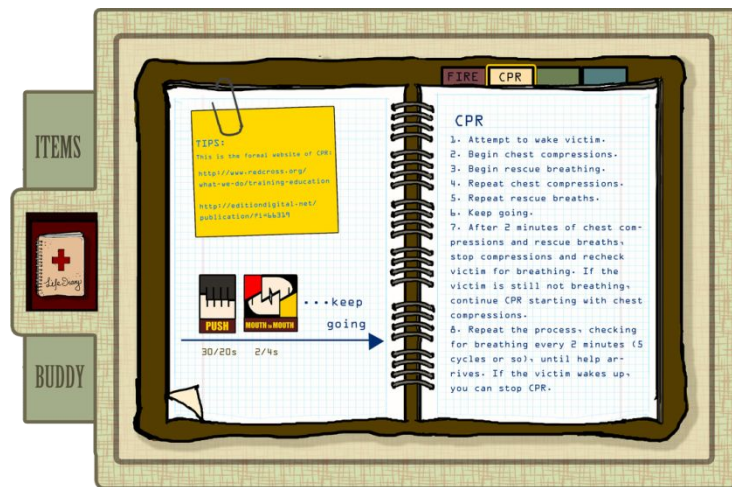
Figure 4.1.4-2: Diary and notebook

The dog dressing system is just a fun collectible mechanic that allows the players to dress Buddy with various items found in the game world.

Figure.4.1.4-3: Dog system

There will be a pop out tips of the inventory menu once the player collects new items, diaries or decorations. Thus the player can enter to that interface directly by clicking the quick enter button ("E")

Figure 4.1.4-4: Pop out tips

The help system can remind players about the operation of the game.

Figure 4.1.4-5: Guide system

4.1.5 Cinematic cut scenes

In order to tell the story and provide some information progress, I used three frame comics to show the story.

We tried to tell the story through graphics and simple symbols, instead of text. Just like *Valiant Hearts: the Great War,* we still provide the text in the Diary interface, but players can choose to read the text or not. We wanted to provide the player with more approaches to obtain the knowledge.

Figure 4.1.5-1: Cut scene

4.2 Animation

Since our game did not need too much animation, I created all the animation in Unity 3D.
Character animations are accomplished through skeleton animation, which means I just
need to create every single movable skeleton of characters instead of every frame. All the
connection points where circular (see Fig 4.2.1-4) in order to provide the character with a
more flexible movement space make the animation more vivid.

4.2.1 Character animation

Figure 4.2.1 shows three characters' skeletons, and also each frame of John's push and
dig sequences, Sarah's walk sequence, and Buddy's idle and walk sequences. The
complete set of all animations can be seen in Appendix D.

Figure 4.2.1-1: John's skeleton
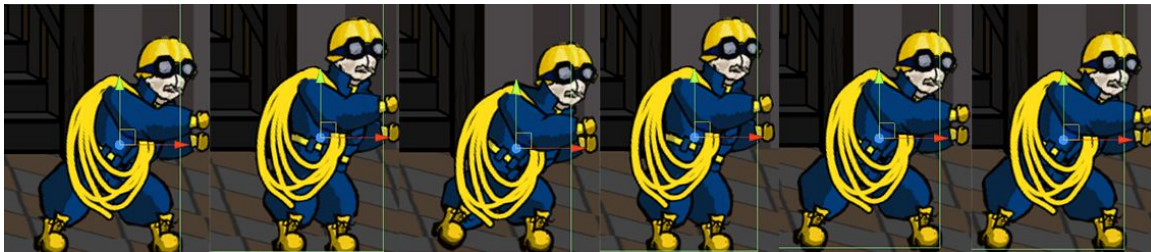
Figure 4.2.1-2 John's push animation

Figure 4.2.1-3: John's dig animation
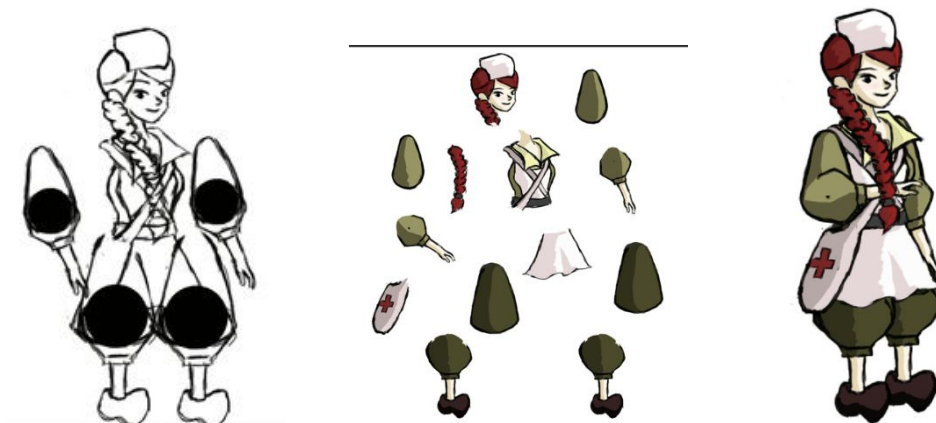
Figure 4.2.1-4: Sarah's skeleton

Figure 4.2.1-5: Sarah's walk animation

Figure 4.2.1-6: Buddy's skeleton

Figure 4.2.1-7: Buddy's idle and walk animation

4.2.2 Items animation

All the items animations are complete in Unity, and all the sprite sheets can be found in Appendix D.

4.2.3 TV animation

We created the TV animation mainly in Keynote. We made all the graphics in Photoshop, and imported them into Keynote. After all the animation effects are almost done, we used Final Cut pro and iMovie to edit the video.

Figure 4.2.3-1: TV Animation

Chapter 5 Game Technology

A game system is mainly made up by three factors: Content, Rules and Parameters. Consider an example of a general combat game:

1) Content: Content is all objects in a game, including characters, opponents and items. Each type of content has parameters that define it, like damage for a weapon, or attributes for a character.

2) Rules: Rules are the functions and formulas that determine the results of actions and events in a game. Rules include aspects like how combat damage is calculated, how character statistics change when they level up, and how random or specific rewards are given.

3) Parameters: Parameters are the values that a game system uses to simulate a game, such as health, movement speed, strength or the chance of a critical hit.

Then the other technologies are about how to implement specific functions in the game as elegantly as possible. For example, there are multiple approaches to define movement functions for a character. Both pressing and holding directional buttons for movement are feasible, with pros and cons for each. Our tech members were responsible for exploring various methods to make them a best fit for *Defying Disaster*.

5.1 Game Scene Technology

In *Defying Disaster*, all levels share many of the same functions. It would saving time by writing common functions for each level. We wrote several "abstract classes" to define objects in game scenes. For instance, the most common technology in the game scene is collision detection. All triggers for events are implemented by collision detection. For efficiently, we created an abstract class called "detect box". We wrote all the triggers function in the abstract class including a character walking into the detect box, character interacting in the detect box and character walking out of the detect box. Then, every "collidable" object's script in all levels could inherit the abstract class. In this way, functions could be reused for other levels. The script logic is shown in Figure 5.1.1-1.
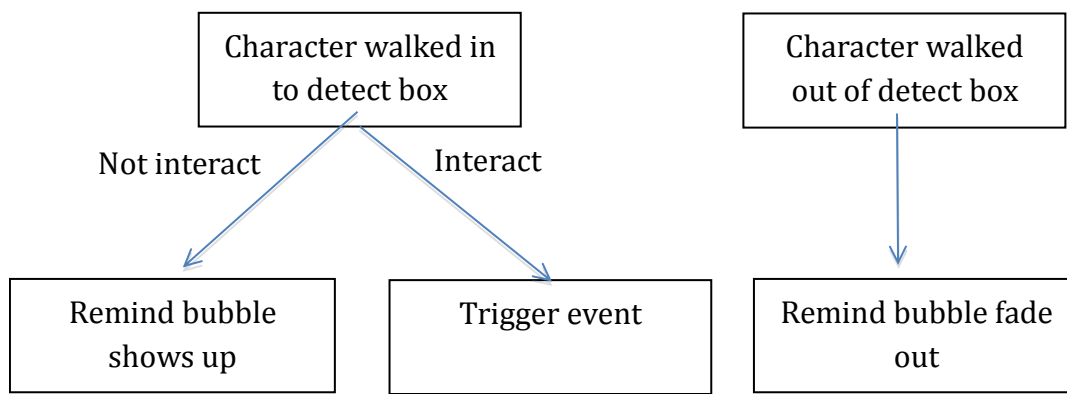
Figure 5.1 - 1: Detect box logic tree

Another technology we used in the game scene is a camera split. For instance, in the process of putting the fire out, players need to do two things, turn off the valve, and use the extinguisher. In order to remind players that the fire has been contained after player turn off the valve, we created another small camera to show the reduced fire animation.

5.2 Mini game technology

5.2.1 Mini-game: Supermarket

The goal of the game is to teach players what items need to be purchased before an earthquake.

Game System

(1) Content: All visible content in this game are divided by two areas. In the left area, there is a checklist and text to represent items in the cart. In the right area, there is the background, cart and cards to simulate a supermarket environment.

(2) Rules: There are 15 cards representing items that can be chosen by players. The cart only has a capacity of 10. 10 items are needed to prepare for an earthquake, and 5 items are incorrect items designed to test the memory for players to remember the right items. Cards randomly pop out and let players choose "buy" or "pass". The concept of "status" comes from "Decision Tree" (a term of Artificial Intelligence (AI) for Games) which means a game AI makes decisions based on different conditions to go to the next status during a game. The game logic is shown in Figure 5.2.1-1.
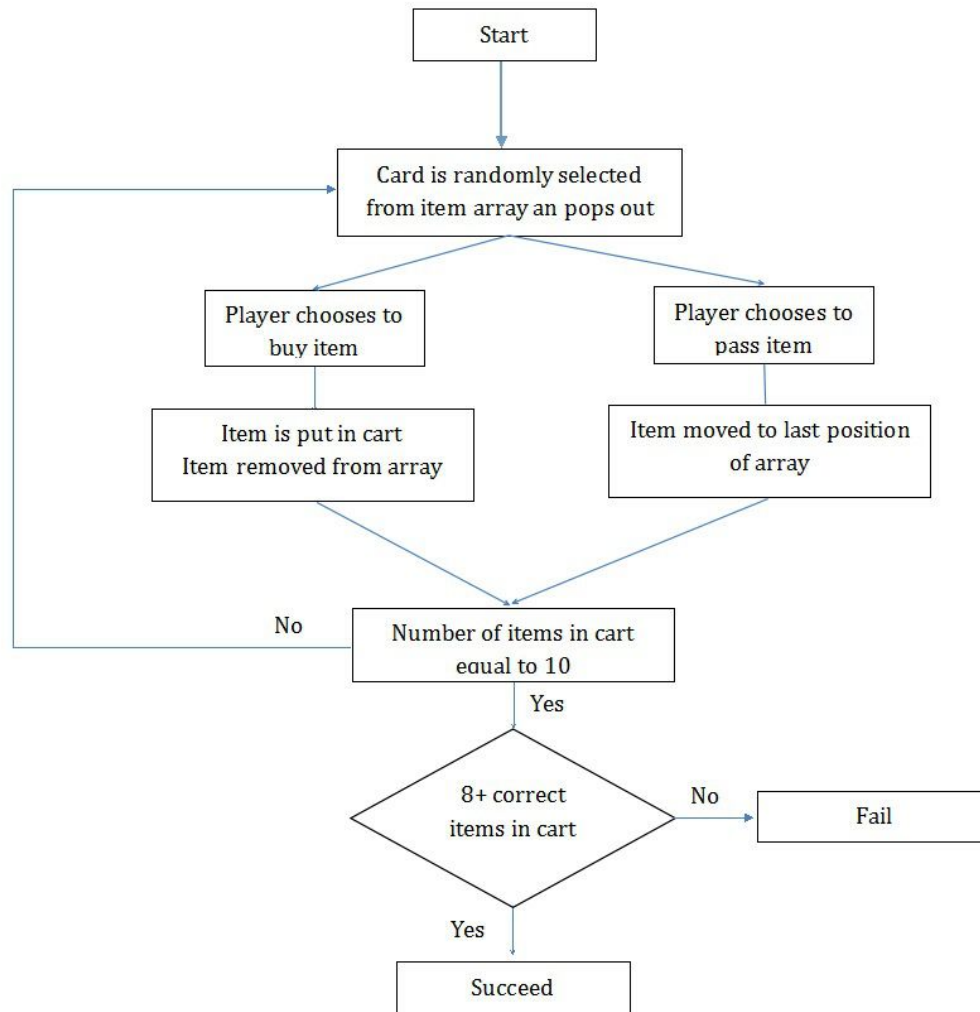
Figure 5.2.1-1: Supermarket game logic

UI components are mainly responsible for displaying current items in the cart. Both right and wrong items are shown in the cart. However, wrong items have a red line above the text to remind players they choose an unnecessary item. All UI components' layouts and parameters are flexibly controlled by code, which is designed to facilitate game testing.

(3) Technologies:

Random number: Random numbers are used to make cards pop out in random sequence instead of a pre-determined order. The task here is to randomly select one card from 15

Yes

cards. The most naïve way is randomly getting a number from 1 to 15 and storing the number into an array, traversing the array to find whether there is a duplicate or not. Even though the number here is small (n = 15), this is still a waste of computing resources. Instead the algorithm designed creates a non-duplicate array with 15 capacities, checking whether it is a duplicate when the number is generated. In this way, this algorithm only compares once instead of comparing with all the elements in the array.

End animation: At the end of the game, players see an end animation to know which items they forgot to buy. Cards are shown one by one to players. The animation is totally controlled by code. We used an array to store data including which items players choose to fix or check and used an update function to control the sequence and position of the cards. Cards appear in different sequence and different position based on players' different choices.

5.2.2 Mini-game: Fix

The goal of the game is to teach players what items in their house need to be fixed or checked before an earthquake.

Game System

Content: All visible content in this game are cards, furniture and background.

Rules: There are 9 cards representing items that need to be fixed or checked. Players need to select fix or check the items before an earthquake. The decision tree is shown in Figure 5.2.2-1.

(1) Technologies:

End animation: At end of the game, players see a checklist controlled by code. We used an array to store data including which items players chose to fix or check and used an update function to control whether the right icon or the wrong icon should be showed according to the item.
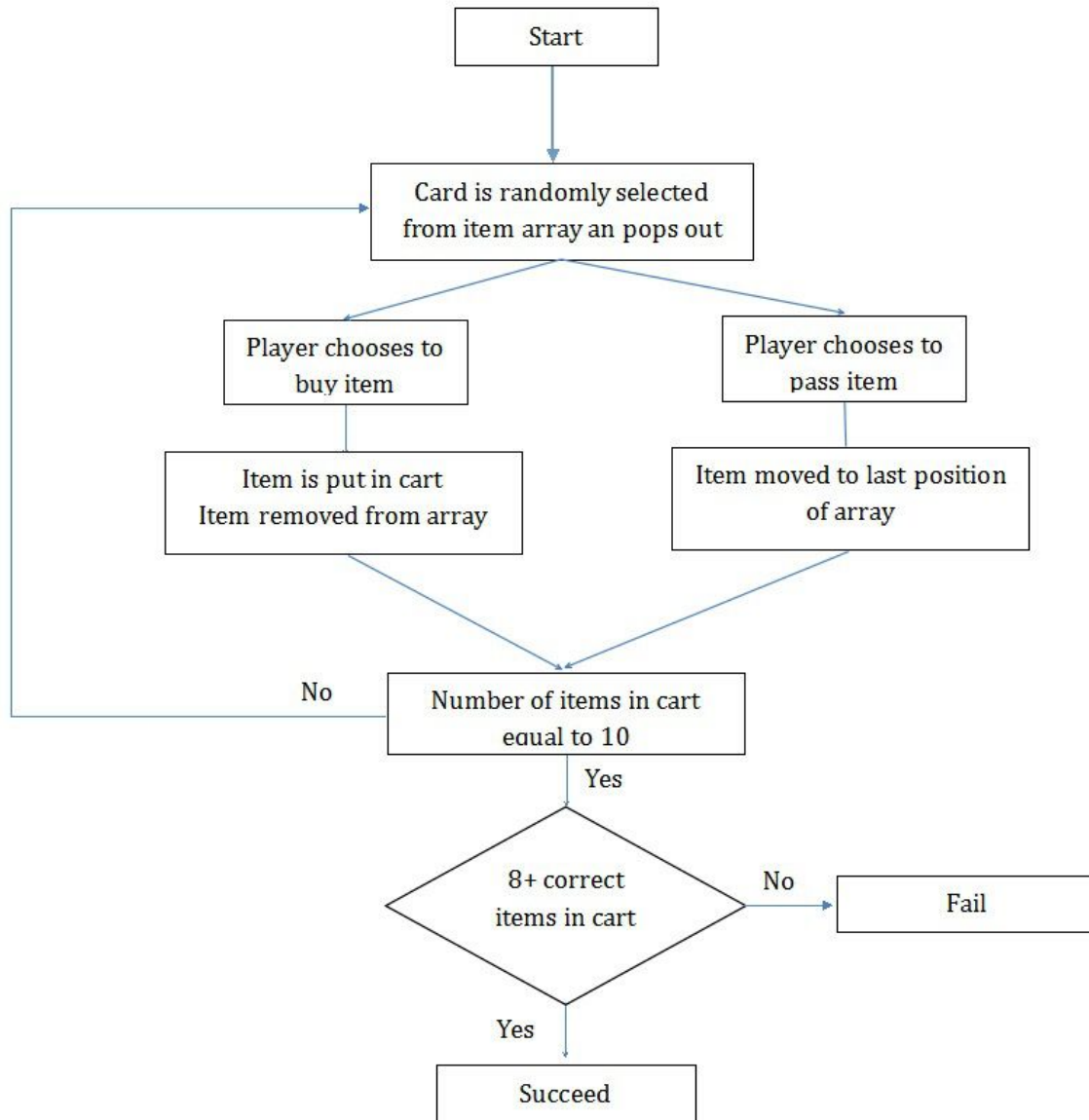
Figure 5.2.1-1: Supermarket game logic

5.2.3 Mini-game: CPR

The goal of this game is to teach players CPR knowledge. Players need to press matching arrows in synch with the background music. The frequency of arrows' appearance needs to exactly be 30 times in 20 seconds. We used an update function to simulate the same frequency. The music also has the same frequency which is 30 times in 20 seconds. In this way, players can learn the frequency of CPR both by touch and by hearing.

Game System

(1) Content: All visible content in this mini-game is arrows, heart and UI components.

(2) Technologies:

Random numbers are used to make every round have a different arrow sequence, which means arrows are generated in random sequence instead of a pre-determined order. To use less time and space to generate random numbers, we use arrays to generate a set of numbers without repetition and store them into an array.

5.2.4 Mini-game: Card

The goal of this game is to show where people should hide when an aftershock happens.

Game System

(1) Content: All visible content in this mini-game is cards and UI components.

(2) Rules: All 12 cards in the game should match except they have different figures (same if they are to be paired). They all have an attribute of paired and unpaired, an attribute of turned over and not turned over, and a unique number which records which card should it be paired with. Game logic is shown in Figure 5.2.4-1.
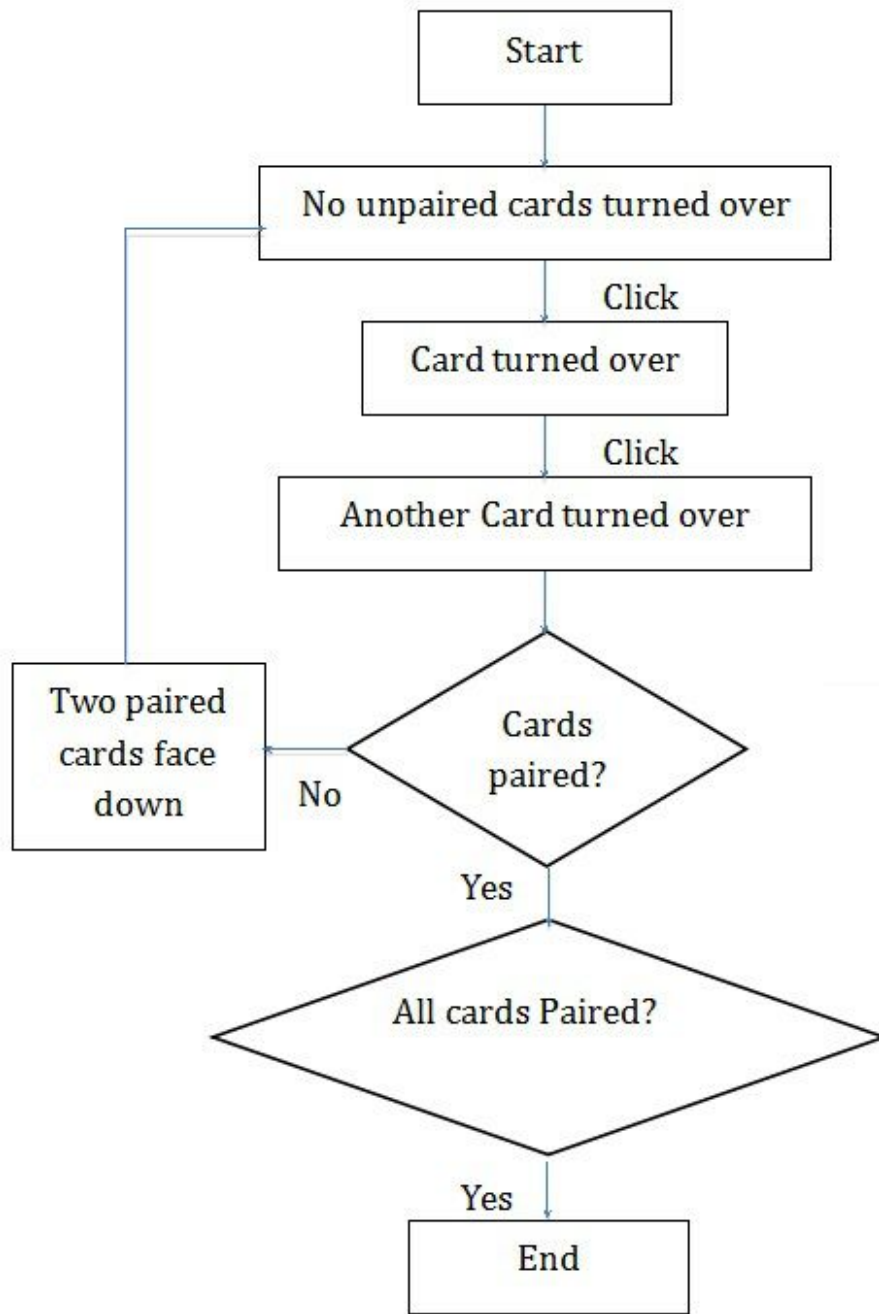
Figure 5.2.4–1: Card game logic

Each game loop, the program (game) waits for player's action to go through the game logic.

UI components mainly display the current cards status and the player's score. All UI scenes list and the 3 "Shouldn't" scenes list are placed left and right respectively and contain 6 fixed positions to hold 6 paired cards, one position for one paired scene (card). If cards are paired, the paired cards are moved to one of the fixed positions in 2 seconds. This is implemented by code instead of animation.

(3) Parameters: A counter displayed on the bottom of screen shows the player's total revealing attempts. At a minimum, players need 12 turns to win the game due to 12 cards in total. If a player wins the game in fewer than 14 times, the player gets a bonus reward. The program decides the next scene automatically based on the value of counter when all cards are paired: "Getting bonus rewards" or "Cannot get bonus reward and game can be tried again".

(4) Technologies:

Random numbers: Similar to the previous mini-game, instead of random for a value, the program initiates an array of size-12 and then initiates values from 1 to 12 (e.g. array[0] = 1, array[11] = 12) to this array in order. Every round, the random index switches value with the last value of the array. As an example, the first round, the random index is 4, the 4th element in this array is 4. Then it is switched with the 12th element, 12. Thus the 4th element equals 12, the 12th element equals 4. In the next round, the random range decreases from 1 - 12 to 1 – 11, which means it will never get index of 12 and 4 will be the last element in the final random array.

This approach has time complexity O(n), which is better than the previous approach since it saves both time and computing resources. Cards are assigned different numbers, 1 and 2, 3 and 4…11 and 12 as paired cards.

5.2.5 Mini-game: Put out Fire

The goal of this game is to teach people using proper tools to put out different fires.

Game System

(1) Content: Three kinds of fire: Red Fire caused by flammable liquids, Yellow Fire caused by regular combustible and Blue Fire caused by electricity/wire. Three tools for putting out fire: Water for only yellow fire, Pile (Sand) for both yellow and blue fire, and Extinguisher for all three fires. The main game scene is a house on fire, which is represented from a top-down view. The character, John, walks around the house to put out the fire.

(2) Rules: All fires and tools are displayed on the top-down view of Sarah's house. The player needs to collect tools and put out the desired fire. However, tools are limited, if the player used an extinguisher to put out a yellow fire, s/he may be unable to put out red fire since it can only be put out by an extinguisher. The game logic is shown as Figure 5.2.5–1.
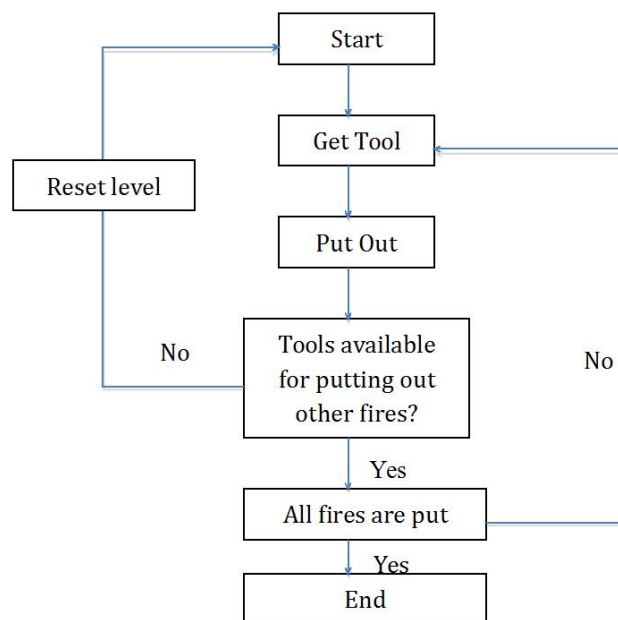
Figure 5.2.5-1: Put out Fire game logic

(3) Parameters: There are no actual parameters displayed on the game scene, only some default settings or limitation.

    a. Player can only carry one tool at most.

    b. 5 tools for 5 fires.

(4) Technologies:

2D Map: In general, maps are configured by placing invisible collision boxes in the game scene. However, collision detection is quite resource consuming, plus a top-view map has more detail, which means it requires many collision boxes, so this approach is not good enough. Therefore, the program instead uses a 2D array to record the map first – zarray, in which one Boolean value represents a navigable area (true -> paths, false -> blocks). In each game loop, the character checks the array to determine if s/he can move in the indicated direction.

Chapter 6 Evaluation

The goal of this evaluation is to discover if our serious game had any impact on learning outcomes. Based on our data, we can clearly see that the people who played the game can remember earthquake survival tips better than the people who read the material.

6.1 Research method

There were thirty subjects in this test, they were divided into two groups (Group A, Group B) and each group has fifteen subjects. Group A read a short article about preparing for an earthquake. Group B played *Defying Disaster*. The subjects in each group filled out three forms: pre-experiment questionnaire, post-experiment questionnaire and an exam about earthquake survival tips. The process is shown in Figure 6.1-1.

Hardware: 30 computers (Higgins Lab 223)

Process:

Subjects		Before test	Test	After test
30 people	15 people	Take questionnaire and exam	Read materials	Take questionnaire and exam
	15 people	Take questionnaire and exam	Play game	Take questionnaire and exam

Figure 6.1-1: Evaluation process

6.2 Research question

In the user test, we made two questionnaires and one exam to test both the earthquake survival tips and evaluate the game.

6.2.1 Questionnaire types

The questions are divided into three types.

1) Multiple-choice questions.

Q3: On average, how many hours do you spend playing video games per week?

☐ Less than 1 hour

☐ 1-5 Hours

☐ 6-10 Hours

☐ 11-15 Hours

☐ 16+ Hours

2) Five scale scoring questions.

Q1: Do you think learning knowledge about disaster through reading materials is a good idea?

☐ 1   ☐ 2   ☐ 3   ☐ 4   ☐ 5

Very Bad   Very Good

3) Open-ended questions.

Q1: Do you actively seek out knowledge about earthquake?

☐ Yes   ☐ No

If your answer above is "No", what factors make you unwilling to do it? (e.g., I think disaster are unlikely)

See whole questionnaires in Appendix A, B, C.

6.3 Result

We collected thirty valid forms, since the test is anonymous; we can only get their age, gender and game experience. Twenty three were male and seven were female. All of them are now in 20 to 25 age range. All of them have game experience.

6.3.1 Pre-experiment Questionnaire Result

In this questionnaire, 21 people did not actively seek out earthquake survival tips (Figure 6.3.1-1). 9 people said they would actively seek out knowledge about earthquakes. However, none of them acquired the knowledge through playing relevant games (Figure 6.3.1-2). Only one of thirty people spends more time on reading books than playing games per week. All of the people think learning knowledge about earthquakes through playing games is a good idea. All these data suggest that playing games is a potential way to teach people earthquake survival tips.
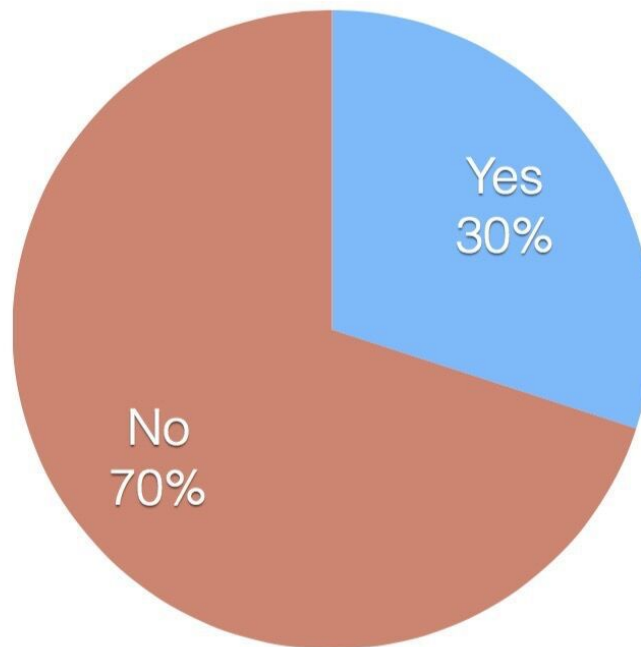
Figure 6.3.1-1: Do you actively seek out knowledge about earthquake?
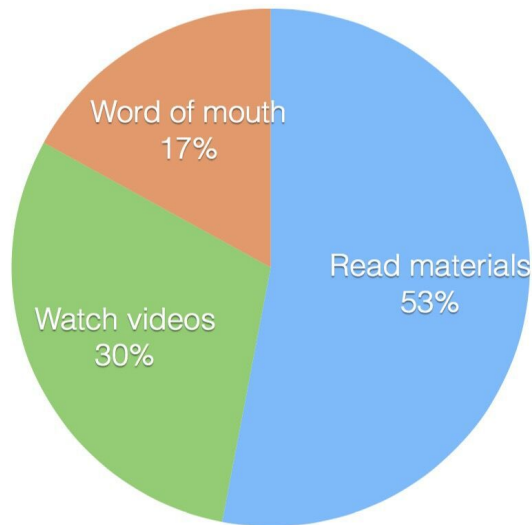
Figure 6.3.1-2: How do you acquire emergency knowledge?

6.3.2 Post-experiment Questionnaire Result

In the post-experiment questionnaire, all answers indicate that learning earthquake survival tips through playing a game is both a good and fun idea. Figure 6.3.2-1 shows that none of subjects believe learning knowledge through playing game is a bad idea. Figure 6.3.2-2 shows that subjects think our game is fun enough - all of them give three or higher score on the question "do you think our game is fun". (From 1: Not at all to 5: Very fun).
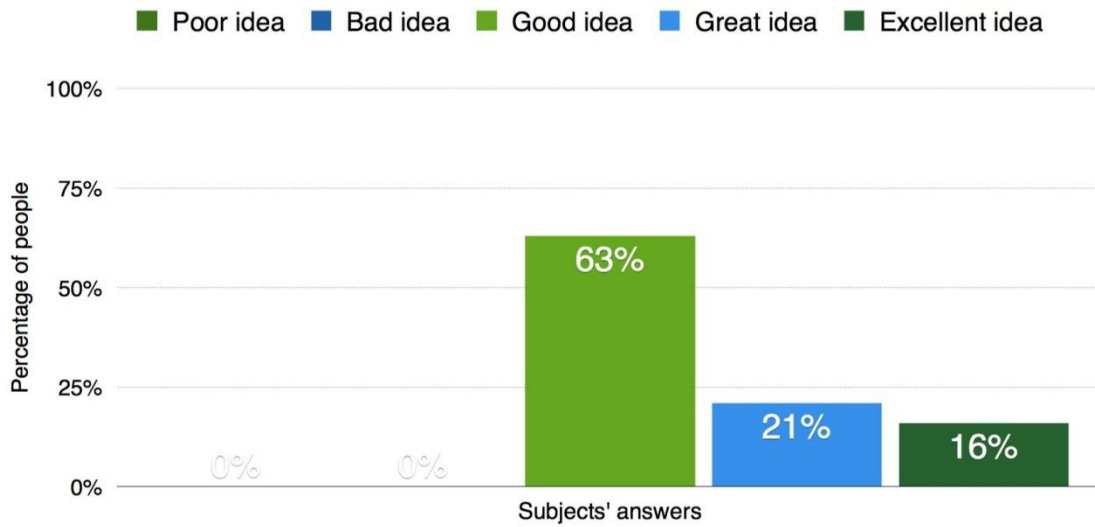
Figure 6.3.2-1: How do you think of learning earthquake survival tips through playing games?
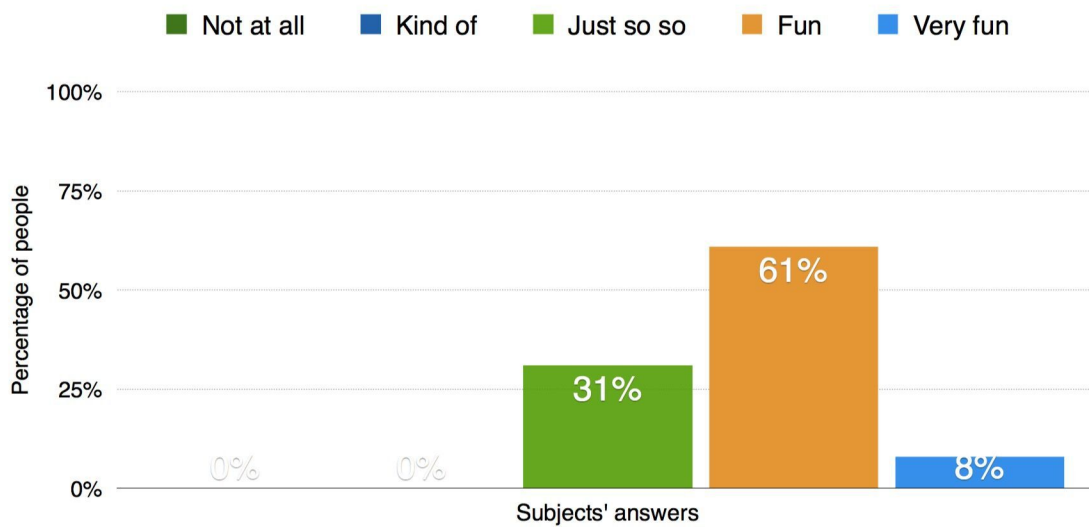
Figure 6.3.2-2: Do you think our game is fun?

6.3.3 Exam Result

Subjects in the reading group did two exams, one done before reading the materials, and the other subjects in game group did the same two exams before and after. Figure 6.3.3-1 shows that playing games can dramatically help people remember earthquake survival tips. The accuracy increases 31 percent from pre-exam to post-exam. In the post-exam, accuracy reaches almost 100 percent. It shows that people can remember knowledge better through playing games than through reading materials.
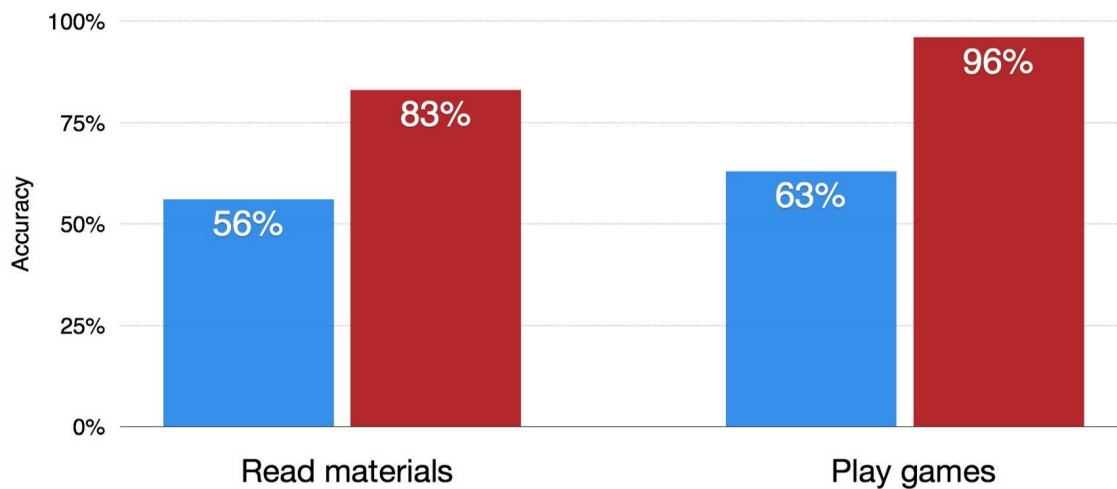
Figure 6.3.3-1: Exam accuracy comparison

Chapter 7 Post Mortem

7.1 What went right?

(1) We envisioned *Defying Disaster* in the beginning, including the art style and gameplay, and the game came out almost as our envisioned.

(2) Our first level of this game as a demo was done before turning to the other levels, this demo helped do the following elements.

(3) The prototypes for most game systems were implemented before doing actual development.

(4) We designed the game based on the limitation of "teaching knowledge", which was effective for serious game design.

(5) Reference art helped for the concept art design.

(6) Some animations were easily done with lightweight tools (e.g; Keynote). For example, we created the TV news by using Keynote. We exported the keynote to video and imported the video to Unity because Unity doesn't support Keynote type file.

7.2 What went wrong?

(1) The original scope of the game is so large that it could not be done within our limited time. We were supposed to finish four disasters (hurricane, earthquake, snowstorm, fire), however in the end only one disaster (earthquake) has been finished within the given time available and considering our team size. Instead, parts of the fire disaster were integrated into the implementation of the earthquake disaster. We also supposed to apply Leap Motion into this game as a controller to help with simulating real CPR process. The idea was dropped due to limited time & not catching up with the schedule.

(2) Some game features had been changed during the development, which did not fit this game anymore. Some of the original designs could not be implemented due to the limitation of art and tech aspects.

(3) The game did not have a simple gameplay/mechanism going through the whole game. This makes the game less of an integrated or uniform experience.

(4) A database management system (save/load in game) should have been designed in the beginning to store, keep track and update game status.

(5) Art style was set up in the beginning, but all the following artworks did not always follow it.

(6) Storytelling for the game was important and should have be written in the beginning.

(7) The lack of communications among tech members, art member and designer sometimes caused redundant and repeated work.

7.3 What did we learn?

(1) The Demo/Alpha version should be used to present core gameplay. However, the demo of this game doesn't show much about gameplay.

(2) Gameplay should be tested before starting to development. Since gameplay is important. It should be tested through the whole development process.

(3) Every team should have a leader or manager. This could help better with tracking with working progress, and enhancing communications between members.

Chapter 8 Conclusion and Future Work

The goal of this thesis was to build a serious game to explore games as an alternative to books for learning disaster knowledge. To do this, we designed a serious game from scratch. We researched and followed serious game design principles and made a 2D side-scrolling game – *Defying Disaster*. Players go through game scenes to tackle multiple problems they may encounter in a real earthquake. With the assumption that players could learn earthquake survival tips during playing our game, we design an experiment mainly to detect if people could learn better through playing *Defying Disaster* than reading related materials. Based on the scores differences between the pre-exam and post exam about earthquake survival tips, we found subjects playing the game learned earthquake survival tips a bit better than those reading materials, which proved our assumption to be true.

However, even though *Defying Disaster* performs well in our experiments, there are areas for future work:

(1) In this experiment, the exam scores for the game and book are almost the same. However, most of the questions in the exam are pretty straightforward. In the future, some elusive or complex questions or tasks (e.g., how to use an extinguisher?) could be used for testing for learning from games verses learning from books.

(2) *Defying Disaster* is only about teaching earthquake survival tips, so there are still a wide range of disaster knowledge that could be explored. As mentioned before, our original scope of this project considered snowstorms and hurricanes.

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Appendix A

Pre-experiment questionnaire

Pre-experiment for both playing game and reading materials:

Q1: Do you actively seek out knowledge about earthquake?

☐ Yes ☐ No

If your answer above is "No", what factors make you unwilling to do it? (e.g., I think disaster are unlikely)

```
┌─────────────────────────────────────────────────────────────┐
│                                                             │
│                                                             │
│                                                             │
│                                                             │
│                                                             │
│                                                             │
└─────────────────────────────────────────────────────────────┘
```

Q2: How do you acquire emergency knowledge?

☐ Read books or materials

☐ Word of mouth

☐ Watch relevant videos

☐ Play relevant games

☐ Other (Please list them below):

```
┌─────────────────────────────────────────────────────────────┐
│                                                             │
│                                                             │
│                                                             │
│                                                             │
└─────────────────────────────────────────────────────────────┘
```

Q3: On average, how many hours do you spend playing video games per week?

☐ Less than 1 hour

☐ 1-5 Hours

☐ 6-10 Hours

☐ 11-15 Hours

☐ 16+ Hours

Q4: On average, how many hours do you spend reading books per week?

☐ Less than 1 hour

☐ 1-5 Hours

☐ 6-10 Hours
☐ 11-15 Hours
☐ 16+ Hours

Q5: Do you think learning knowledge about disaster through playing a game is a good idea?

☐ 1   ☐ 2   ☐ 3   ☐ 4   ☐ 5

Very Bad   Very Good

Appendix B

Post-experiment questionnaire

Post-experiment for reading materials:

Q1: Do you think learning knowledge about disaster through reading materials is a good idea?

☐ 1   ☐ 2   ☐ 3   ☐ 4   ☐ 5

Very Bad   Very Good

Q2: Do you think the knowledge you gain from reading materials could help you survive when a real earthquake/fire happens?

☐ Yes   ☐ No

If not, why not? (e.g., I still don't know how to use an extinguisher)

```
[blank text box]
```

Q3: How much are you willing to learn knowledge though reading?

☐ 1   ☐ 2   ☐ 3   ☐ 4   ☐ 5

None   Much

Post-experiment for playing game

Q1: How do you think of learning emergency knowledge through playing game?
(From 1: Very poor idea to 5: Excellent idea)

☐ 1   ☐ 2   ☐ 3   ☐ 4   ☐ 5

Q2: Do you think this game experience could help you survive when a real earthquake/fire happens?

☐ Yes   ☐ No

If not, why not? (e.g., I still don't know how to use an extinguisher)

```
[blank text box]
```

Q3: Did you notice the pop-out tips when playing the game?

☐ Yes   ☐ No

If so, did you read them carefully?

☐ Yes   ☐ No

Q4: After research, will you look up relevant materials to find out detailed knowledge about what you encountered during playing our game (e.g., more detail about what kinds of fire should be put out by specified tools)

☐ Yes   ☐ No

Q5: Do you think our game is fun?

(From 1: Not at all to 5: Awesome**)**

    ☐ 1   ☐ 2   ☐ 3   ☐ 4   ☐ 5

Not at all   Very fun

If yes, can you specify some examples?

| |
| |
| |

If no, can you tell what parts degrade playability?

| |
| |
| |

Appendix C

Exam

Testers need to take two exams. The first is before they read materials or play the game. The second is after they read materials or play the game.

Q1: Which food should you choose to store before an earthquake?
☐ Bread and Milk   ☐ Can   ☐ Beef   ☐ Apple   ☐ Water

Q2: Which items should you prepare before an earthquake?
☐ Dust mask   ☐ Local Map   ☐ Corkscrew   ☐ Helmet   ☐ Radio

Q3: Which items need to be checked or braced before an earthquake?
☐ Mirror   ☐ Bed   ☐ Refrigerator   ☐ Picture
☐ Wire   ☐ Oven   ☐ Picture   ☐ Light

Q4: Which items should you secure before an earthquake?
☐ Ceramic   ☐ Glass   ☐ Valuable items   ☐ Insecticide

Q5: What should you do when you are buried beneath the rubble from an earthquake?
☐ Shout for help
☐ Do nothing to preserve energy
☐ Tap on a pipe or wall so rescuers can locate you
☐ Try to move ruins away to find a way out

Q6: Where do you think is the right place to hide during an earthquake?
☐ Under a table
☐ Next to the window
☐ Under a bed
☐ Inside a closet

Q7: What options do you think is the right way to perform CPR (cardiopulmonary resuscitation)**?**
☐ Use 30 chest compressions at rate of 100 times per minute to every one breath
☐ Use 30 chest compressions at rate of 100 times per minute to every two breaths
☐ Use 40 chest compressions at rate of 100 times per minute to every one breath
☐ Use 40 chest compressions at rate of 100 times per minute to every two breaths

Q8: Can you use water to put out a fire caused by oil?

☐　　　Yes　　　　　　　　☐　　　No　　　　　　　☐　　　Not　sure

Q9: Which way do you think is the right way to put out a fire caused by an electrical short?

☐ Water　　　☐ Sand　　　☐ Dry powder extinguisher　☐ Foam extinguisher

Q10: Which is the right way to let smoke out?

☐ Sprinkle water
☐ Open a window and a door
☐ Use a ventilator
☐ Turn on the fan

Appendix D

Game Art

Game scene

Character Animation

Animation - John - Idle

Animation - John – Walk

Animation - Sarah- idle

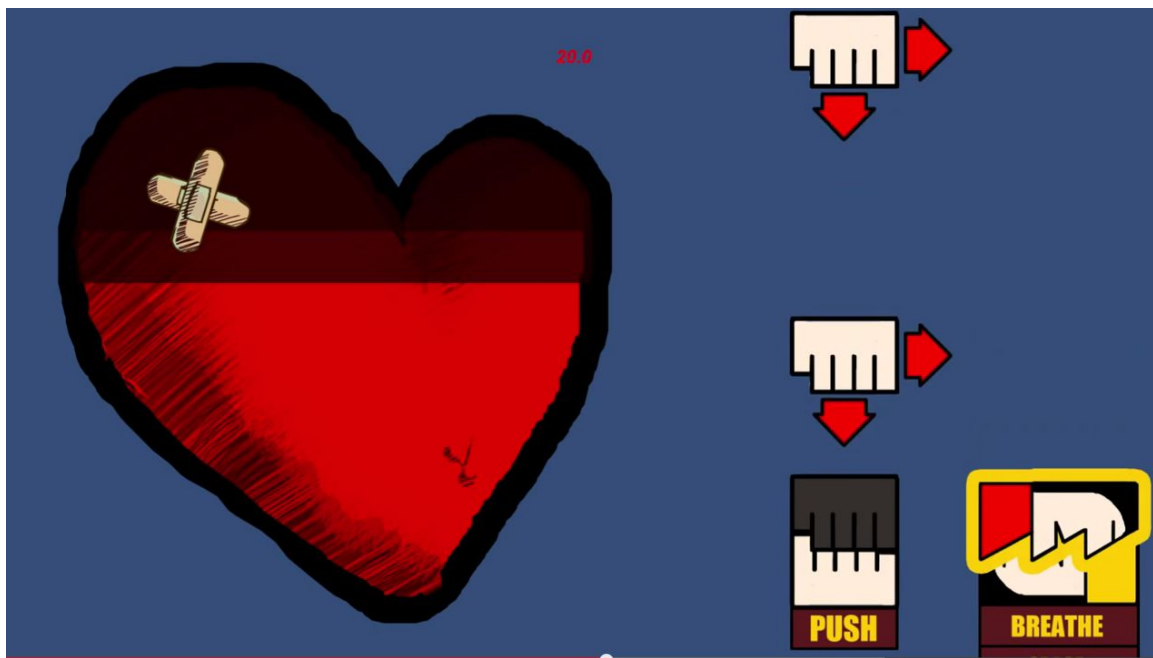Items animation

Item Animation -Fire

Item Animation -Water

Reference art of concept art

Mini game art

Mini game CPR
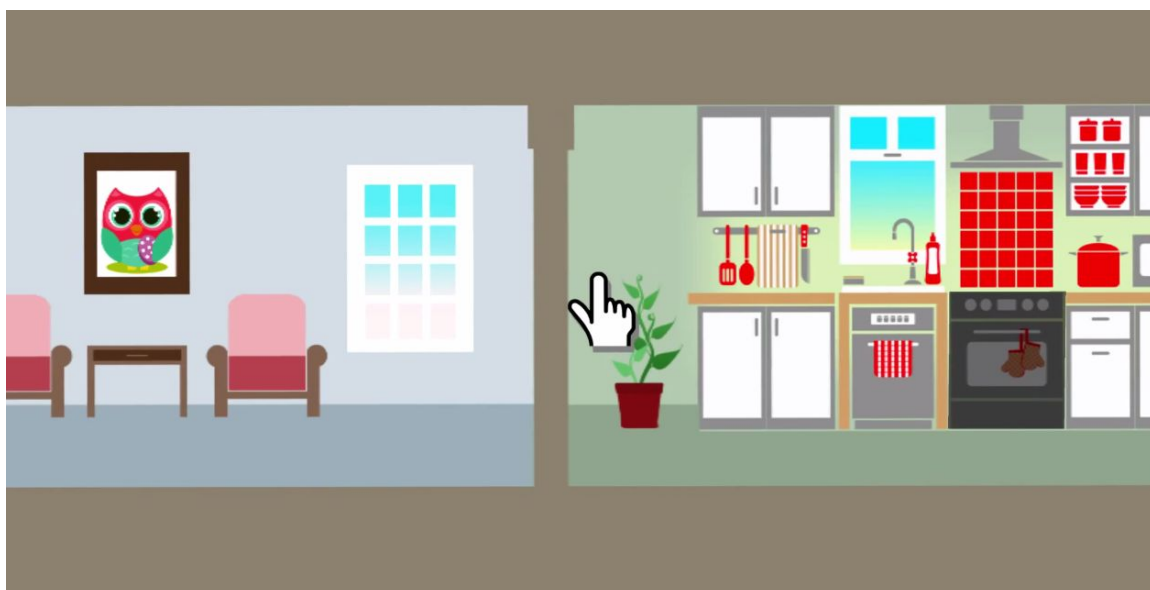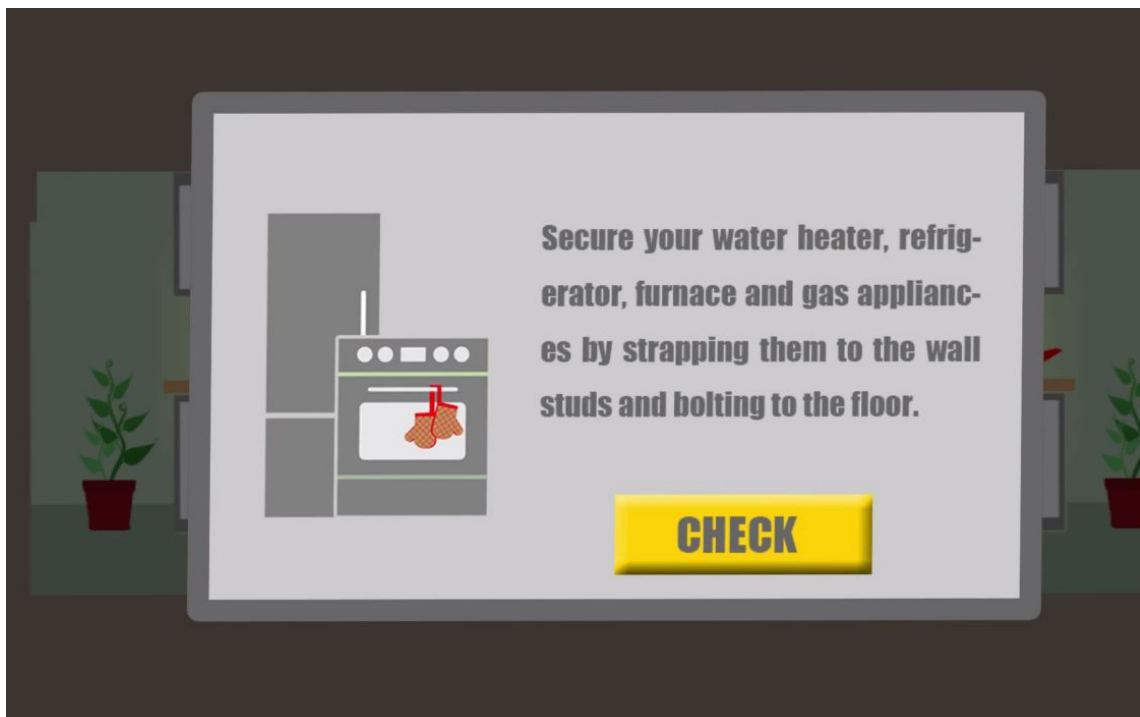
Mini game- Secure your home

Mini game- Put off the fire

Mini game- Card Game

Where you
SHOULD hide

Where you
SHOUDN'T hide

USE PILLOWS TO PROTECT
NECK & HEAD
WHILE LYING ON BED

COVER UNDER
TABLE

COVER UNDER
BED
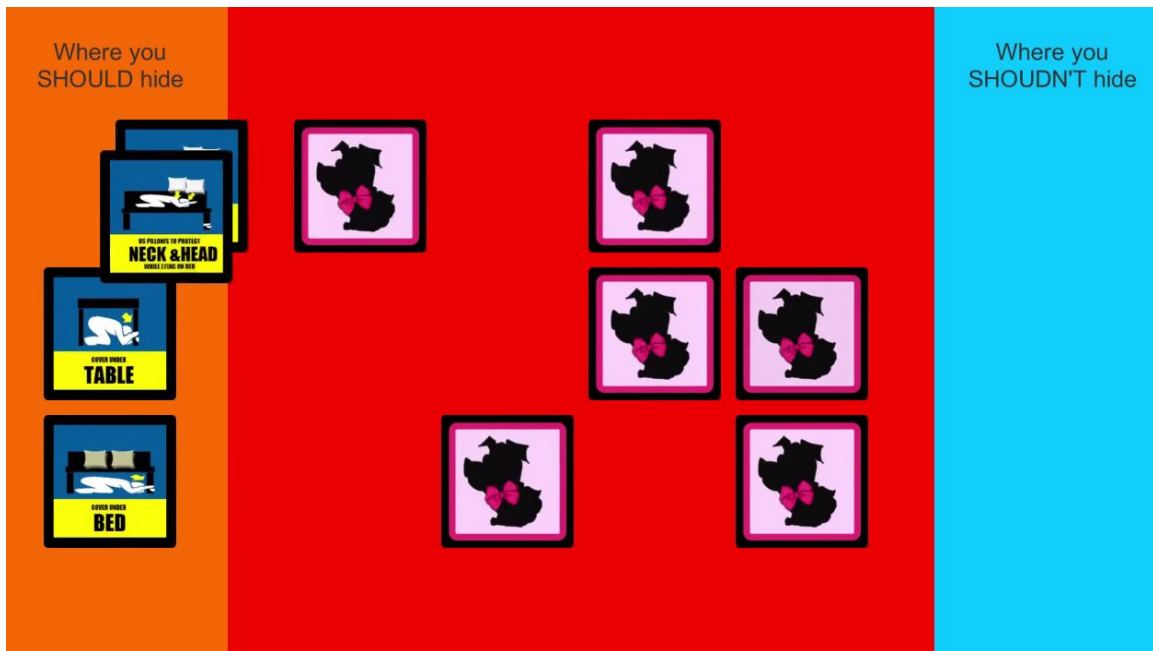
Mini game- Card Game

Appendix E

Proposal

***Defying Disaster*: A Teaching Game for Disaster Preparedness**
IMGD MASTER'S PROJECT PROPOSAL

I. SUPERVISOR & COMMITTEE MEMBERS

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II. GOAL

A. PRIMARY GOALS
Defying Disaster is a serious game with the features of an adventure game, aiming to teach people professional knowledge and training skills about preparing for and dealing with disasters in an immersive and interactive environment. In order to get professional knowledge about disasters, we are currently in talks to partner with disaster preparedness experts at the Federal Emergency Management Association (FEMA).

FEMA responsibility:
1. Provide professional knowledge about disaster. With FEMA's help, we can guarantee the knowledge players learn is accurate and can actually be used in disasters.

2. Provide advices whether the game content is appropriate for players to learn disaster knowledge.
3. When the game is finished and FEMA think the game is helpful to people. FEMA may put the game on their website help us promote game.

This will involve:

- Designing the game to be a method of education. The game will teach players tips to prepare for and survive various natural disasters.

- The advantages of using Leap Motion

Leap Motion supports the recognition of different hand gestures.

One of the advantages is to strengthen the playability; players have more fun by performing numerous gestures when playing the game. We want to prove that is true in playtest part. In comparison with traditional consoles, the game operation based on Leap Motion can allow the player to have an immersive experience in the game.

Another advantage is the promising market of Leap Motion. For now, Leap Motion app store has about 15 games since it is a new technology to people. And all the games are simple and look like demos not a game. We will get good distribution through the Leap Motion app store.

- Keeping the balance between educational value and playability.

We will add entertainment elements, but also make sure the game is still a serious game. We intend to keep the tone light, through our art style and animations.   We will show the player how they died through comical cutscenes when they forget to do something. We hope these death animation can help people remember what to do in the disaster, which will make player laugh and have fun.

B. PLATFORMS

We are targeting Windows, and Mac OS X as platforms for the release of two versions of *Defying Disaster*.

One version of *Defying Disaster* will use a traditional controller, such as a mouse and keyboard.

Another version of *Defying Disaster* will combine a traditional controller with the Leap Motion controller.

The Leap Motion controller is a small USB peripheral device, which is designed to be placed on a physical desktop, facing upward. Using two monochromatic IR cameras and

three infrared LEDs, the device observes a roughly hemispherical area, to a distance of about 1 meter. The LEDs generate a 3D pattern of dots of IR light and the cameras generate almost 300 frames per second of reflected data. The data is then sent through a USB cable to the host computer, where it is analyzed by the Leap Motion controller software. The Leap Motion software synthesizes 3D position data by comparing the 2D frames generated by the two cameras.

With Leap Motion, players can have totally different experience when playing the game.

1. With motion controller, players can remember gesture more impressively than reading materials because players can actually do the gesture. Familiar with gesture can help players save themselves and others during disaster, such as CPR, bind up a wound and etc.

2. With motion controller, players will feel more immersive because players do what the character do in the game. For example, players can use grab gesture to grab things, use pull gesture to pull the things and etc.

3. Players prefer to try something new rather than to stay on traditional controller.

B. GAME DESIGN

a) Overview

Before we think what our game looks like, we found two disaster games on the FEMA's website. (http://www.ready.gov/kids/games)

First game is a text adventure game. We think text adventure game just combine the game with reading materials. The game more like an e-book and players have few interactions with the game. All the actions players need to do is clicking the mouse, reading text, clicking the mouse and reading text again.

Second game is a simple puzzle game about builds a kit. Players need click the items they think the item should in the kit. That's all the game.

After we tried two games, we feel there isn't a game, which can attract players' attention and also teach players disaster knowledge. So we want to build a game that players can learn disaster knowledge when they actually enjoy playing game and immerse themselves in the game.

Defying Disaster is a serious game using both a traditional controller and a somatic controller – Leap motion. The purpose of the project is to teach people how to prepare for and survive three types of natural disasters: hurricanes, earthquakes and snowstorms. The

player will be assessed on their preparation and may face a variety of animated deaths, depending on their level of success. The only way to escape from death is by fixing every problem that may happen in one disaster. Problems contain puzzle games, interactive games and time collecting games.

In addition, Leap motion also brings more fun to this game; hand recognition enables an immersive and interactive process. For example, when players feel that they finished all the tasks or they cannot continue the game, they can click the button to play the death animations, which can remind players missing clues.　Compared with the traditional mouse/ keyboard operation, players can just use the thumb-up gesture to see whether they survive from the disaster successfully. Therefore, players can get a more immersive experience by using such emotional gestures.

b)　Game flow

Figure 1 and 2 represent game flows and include how the game system works in general.
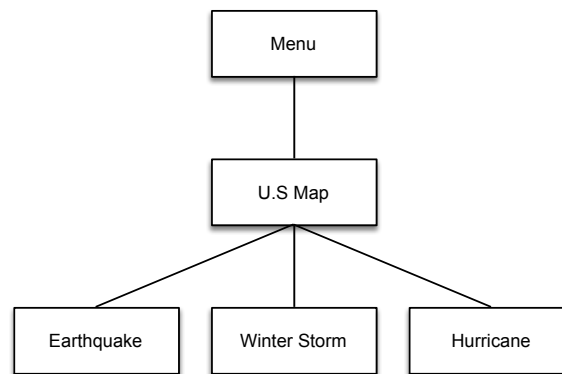

Figure 1 Game menu

In the menu, when players chose start game option, they will see a U.S map. The map shows what specific disaster's possibility in each state. In our game, there will be three disasters can be chosen, earthquake, winter storm and hurricane. Each disaster divided into two parts, preparing for disaster and surviving during disaster.
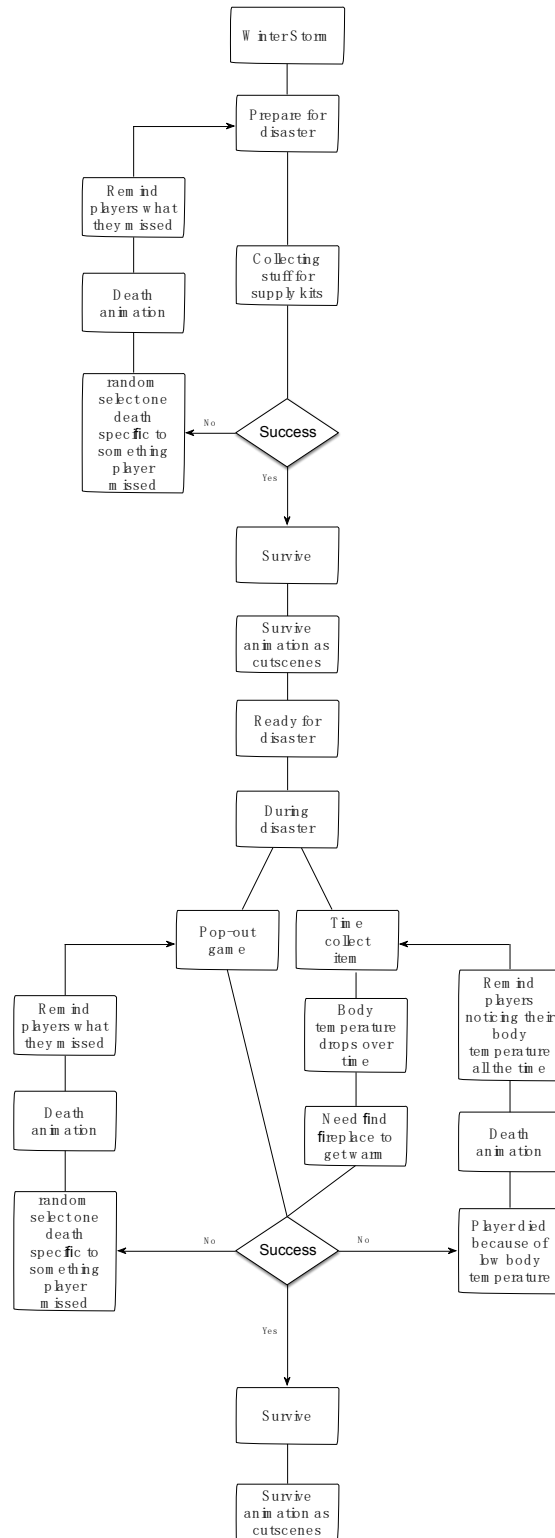
Figure 2 Example of one disaster

Collect stuff for supply kit: Players need collect necessary items during preparation phase. Necessary items can be built up a supply kit, which players will use supply kit during disaster.

Time collect item: Players need find the items. At same time, players also need pay attention to their physical condition. For example, in winter storm, players should always pay attention to their body temperature during finding items.

Pop-out game: There will be several pop-out games in each disaster. When players need fix something to prevent or protect themselves during disaster, there will be a game pop out and show upon the game scene. Pop-out game will strengthen the player's familiarity with the knowledge.

Death animation: Every time when players feel they completed every mission. They can put their thumb up or click the finish button. If players forgot to do something, which can cause player's death, system will randomly select one death animation from the things players forgot to do.

c)   Sample of play

There will be a pop out game in winter storm, which teach people to use minimal snow-melting agent to protect the roof. The roof is not smooth. With different height and gradient of the roof, the snow accumulation will be different. Based on common sense, the snow in lower roof will be deeper than snow in higher place.   However, the maximum load-bearing value of different roofs is same. Players will die from broken roof caused by heavy snow. (This will be presented by a comical animation, which remind players to rethink the right line of melting the snow.)

In this game, players need to find the correct snow-melting agent firstly. There will be two types of the snow-melting agent (organic and inorganic) in the house, players need find them and put them into the backpack. Secondly, with the correct snow-melting agent, a pop out game will be triggered.

There will be two version of the game: Leap motion version, mouse/ keyboard version. In mouse/ keyboard version, players should click the mouse to choose the snow-melting agent, and draw a line in which players think it is the right place to melt the snow. If players think they finished the level, they can click the finish button to see whether they will die from the broken roof.

In Leap Motion version, players need to use their fingers to draw lines, which are necessary to sprinkle snow-melting agent, using a grab gesture to grab snow-melting agents, then using a pour gesture to pour it. If players think they finished the level, they can use the thumb-up gesture to see whether they pass the level successfully.

C. PLAYTEST

The purpose of the playtest is to get feedback from the players. We can get information about the playability of our games, the logicality of the mini game and level design and etc. With this information, we can optimize the game according to their feedback.
During playtest, we will give players questionnaire after they played the game.

The questionnaire will include these questions:
Time:
1. In each disaster, how much time did players spend in total to finish?
2. In winter storm, there will be 3 pop-out games, how much time did players spend in each pop-out game?
3. In earthquake, there will be 2 pop-out games, how much time did players spend in each pop-out game?
4. In hurricane, there will be 3 pop-out games, how much time did players spend in each pop-out game?

Difficulty:
5. In each specific game, there will be five options, 0 represent too easy, 5 represent too hard. So how much scores will you give each specific game according their difficulty? Please give the reason why you think the game is hard shortly in below.

User Interface:
6. Is the user interface laid out well in menu?
7. Is the user interface laid out well in each disaster?
8. Is the user interface laid out well in each pop-out game?
(Please give the reason why you think the UI laid out badly in below)

Control:
7. For mouse/keyboard controller, is it comfortable to use?
8. For Leap Motion controller, is it comfortable to use?
9. If you can only choose one controller, which controller does you chose, mouse/keyboard controller or Leap Motion controller? Why?

Playability:
10. In each specific game, there will be five options, 0 represent bad experience, 5 represent good experience, so how much scores will you give each specific game?
(Please give the reason why you think the experience is bad in below)

General:

12. What part do you think is the worst in each disaster?

User Interface

Game scene

Story logic

Collect items for supply kits in preparation

Pop-out game

Time-limited collect game

(If you can, please describe why you think the part is the worst part in detail)

D. PUBLIC DEMONSTRATION

We want our game available on steam and Leap Motion app store. Right now, we are talking with FEMA to feature it on their website. We also will build our own website to provide the information about the game.

WPI's Student Showfest will be taking place. For Showfest, our game will be showed to the public as a completed version.

In addition to the public demonstration at WPI, we would like to show our game at games festivals and expos, such as PAX East 2015.

III. PARTICPANTS

Our team consists of four members - two Technical Focus Area students and two Serious Games Focus Area students. Game design will be carried out by all of the team members. Some roles, such as user test, sound design, art design, are carried out by multiple team members.

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IV. MOTIVATION

Leap Motion can bring gesture control to personal computer. This Leap motion – a small controller can respond to pinches, grabs, and swipes gestures in the air. We believe this new interaction cannot only bring fun to games but also more profound meaning.

Defying Disaster is such an exploring step; serious game has been more popular than ever. We choose "Natural Disaster" as the theme because natural disasters cause tremendous number of deaths every year. We sincerely hope that through teaching people these useful skills and knowledge, it could help more people save themselves and others. Immersive and interactive experience Leap Motion brings could make disaster knowledge more impressive than it does by reading. We volunteer to be a "teacher" in *Defying Disaster* to help people survive in natural disasters.

V. TIMETABLE

The timetable for the completion of a Master's thesis in Interactive Media and Game Development is outlined below.

Spring 2014 C Term
- Game design
- Initial research

Spring 2014 D Term

- Master's project proposal
- Partnership talks with FEMA
- Mock-up of one scene

Summer 2014
- Unity training
- Original concept art
- Leap Motion programming training
- Basic movement programming
- Basic game scene interactive

Fall 2014 A Term
- Time-limited collect game implementation
- Background Art assets
- Character design and animation
- Develop Art pipeline
- Level design
- Sound design
- Get approval from IRB

Fall 2014 B Term
- Pop out game implementation
- Add Leap Motion control
- Animation
- All assets in-game
- Sound design

Spring 2015 C Term
- Optimize game performance
- Bug fixing
- Release candidate
- Learning study

Spring 2015 D Term
- Building website for game
- Public demo (PAX East)
- Public demo (WPI Student Showfest)
- Writing report

VI. REQUIRED RESOURCES

The following is a list of resources—software, hardware, accessories, and training—that may be used by the participants over the course of the project.

Software
- Unity
- Leap Motion Software

Hardware
- 5 Leap Motion Hardware

The reason why we need five Leap Motion is in evaluation part, five Leap Motion can reduce the test time for all players.

VII. METHOD OF EVALUATION

Overview
Comparing the learning outcomes between test subjects who are given reading material on disaster preparedness from FEMA website, the Leap Motion version of the game, and the traditional controller version of the game. We will then give each group a short test on the material and assess which group retained it best.

Subjects
WPI undergraduate students and other people who want play the game

For evaluation part, the more people involved, the more accurate result data we can get. So we decided invited all WPI undergraduate students who want play the game. We can guarantee the minimum number of people for evaluation.

And all people who want play the game are free to come.

Device
Computer running Windows / Mac OS
Leap Motion

Method:

1. Set subjects into to three groups: one group reads materials, one group plays game with traditional controls, and the last group plays game with Leap Motion

controls.

2. Letting experimental group play specific disaster level (earthquake, hurricane or snowstorm). Control group will learn the knowledge about the same disaster by reading relevant materials offered by FEMA.

3. A test about this knowledge will be held to test if subjects have mastered the knowledge. The result of the test will be used to evaluate the performance.

VIII. Resources

Leap Motion: A computer hardware sensor device that supports hand and finger motions as input, analogous to a mouse, but requiring no hand contact or touching, www.leapmotion.com

IRB: The WPI Institutional Review Board (IRB) was established to help investigators understand and comply with the ethical guidelines and regulatory requirements for research involving human subjects. The IRB's overall goal is to promote and support efforts to conduct innovative research at WPI, which protects the rights and promotes the welfare of human subjects. The test mentioned above need submit to IRB to get approval before the test began.

FEMA: The Federal Emergency Management Agency (FEMA) is an agency of the United States Department of Homeland Security, www.fema.gov

Build A Kit knowledge: www.ready.gov/build-a-kit

Hurricanes knowledge: www.ready.gov/hurricanes

Winter storm knowledge: www.ready.gov/winter-weather

Earthquake survival tips: www.ready.gov/earthquakes

Appendix F

Design Document

1 Overview

Defying disaster is a 2D serious game that is playable on PC or Mac. The goal is to teach people how to prepare before earthquake and how to save themselves and others during disaster. The game has three levels. In each level, there are mini games to teach people about disaster preparedness and interactions in the game scene to increase the gameplay and teach people knowledge.

2 Game mechanics

This part includes the level goal, level flow, victory condition and gameplay design. We separated the whole game into 3 levels. Each level has two or three mini games.

2.1 Preparation level

The preparation level is the first level of the game.

2.1.1 Level goal

The game goal is making players know some knowledge about preparing before an earthquake. And we also want players be familiar with the basic composition of the scene.

2.1.2 Level flow

In the prepare level, player is born outside the house. Then player need to enter house, find the television. Click and enter TV, the television will broadcast the news. After the news, player will play two mini games. One is "Supermarket", another is "Repair and Check".
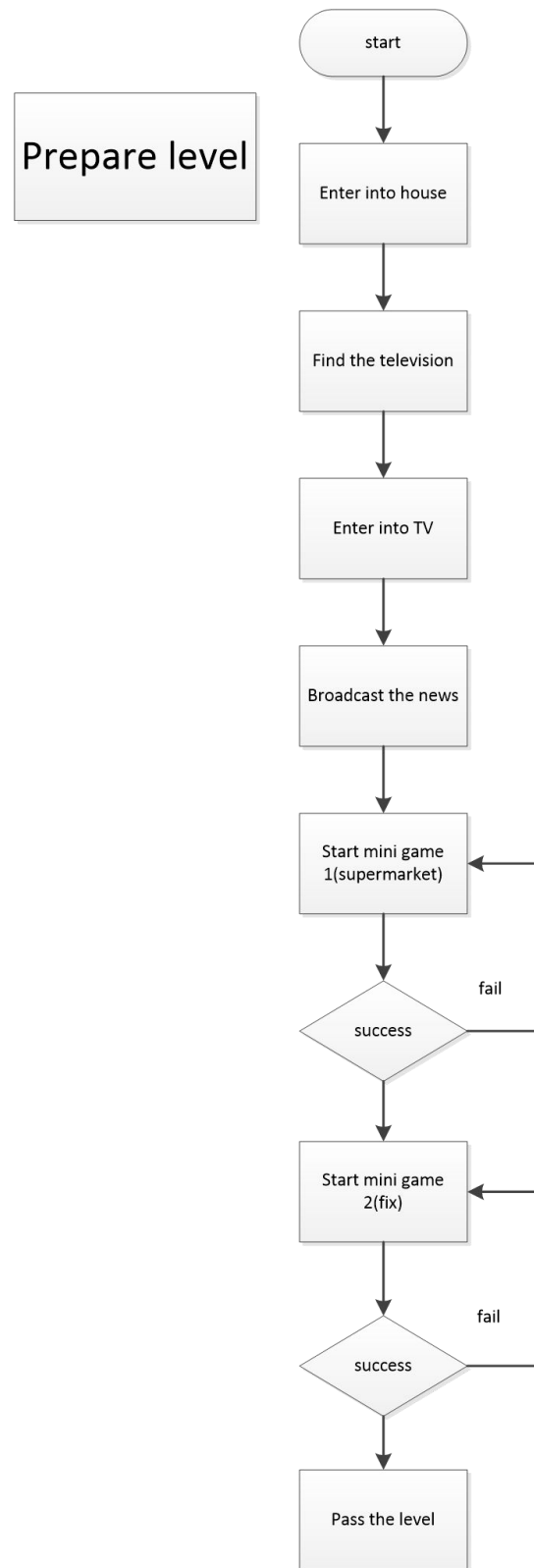
Figure 2.1.2-1: Game flow of preparation level

2.1.3 Victory condition

In "prepare level", the victory condition is that the player must finish two mini games. One is the supermarket game, another is the game for preparing the player's room and furniture before earthquake. If players past these two mini games, this level will be succeed.

2.1.4 Gameplay design

After player enters into the game, we have a simple area for them to explore without puzzles, making them familiar with the basic controls and what areas on the screen can be explored.

Even though there are not puzzles, there are hotspot areas for the player to explore, they can click on pictures hung on the wall, or a cup on the table and get a humorous description or other joke. We intend to bring some light-hearted fun early in the game to offset the serious tone of the rest of it.

The player can also interact with a television to hear a broadcast about the earthquake and ratchet up the tension.

2.2 Level 1

In level 1, player needs to find a way to Sarah who is trapped in her house. After player saved Sarah, player can control Sarah, who is a nurse, to perform professional medical treatment.

2.2.1 Level goal

The goal of the level 1 is less about actually preparing for an earthquake and more about teaching players the affordances in the game space. The factual information about preparing is contained the mini-games and the later levels.

2.2.2 Level flow

Players need to solve puzzles in level 1 according to game flow. First, finding the axe and shovel underground. Second, using axe to get the extinguisher. At the same time, the characters need to turn off the valve by compass. Third, the extinguisher can put off the fire. Then Saving Sarah after digging out the ruins by shovel. The final victory condition is using Sarah to save the wounded by CPR. When player finished these puzzles sequentially, level 1 is over. The following figure is about the level flow.
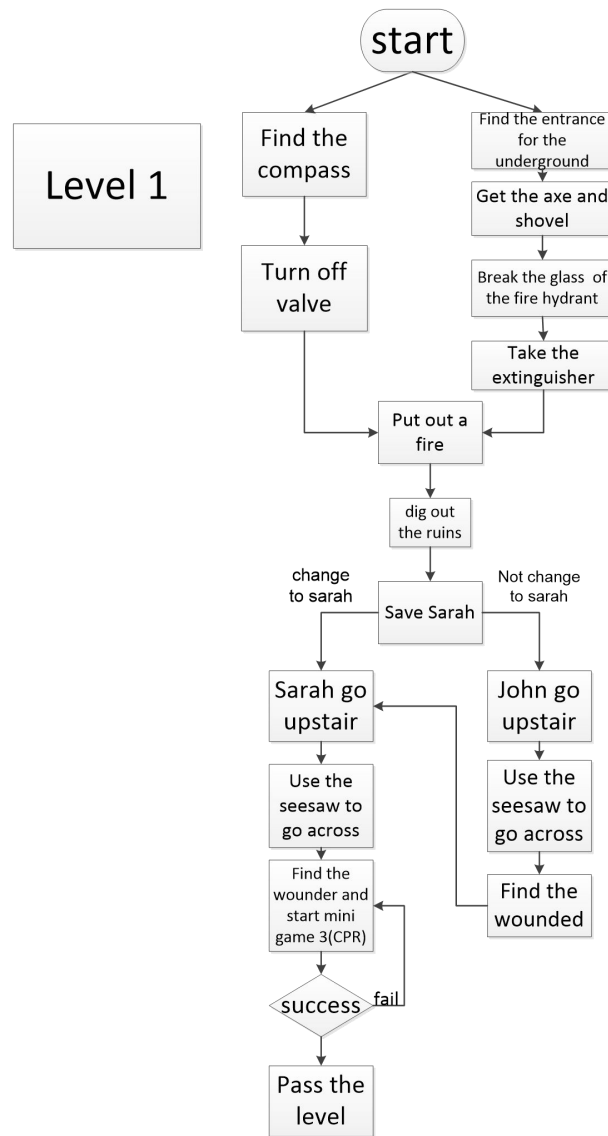

Figure 2.2.2-1: Game flow of level 1

2.2.3 Victory condition

Player needs to do three steps. First step is to put out a fire in the first floor. Second step is to remove the ruins by using shovel. Third step is to switch to another character, Sarah, to go upstairs, and save the wounded people by passing the CPR game.

2.2.4 Level 1 design

A diary will pop out when players successfully solve each puzzle. When players solve every puzzle and pass the level, the diary will include all the knowledge points and related materials for players to read. For example, when players pick up the extinguisher, we will let players know how to use the extinguisher by using the diary. After players put out a fire, the diary will contain the four ways to put out a fire: isolation between fuel and the fire, isolation between oxygen and the fire, decreasing the temperature of the carburant, and chemical inhibition.

In the game, there is no dialog between characters. We try to use simple images to guide the player towards what to do next.

In an earthquake, fire is the most common subsequent disaster. In the first level, we designed a puzzle to teach people how to put out fires and remind them to turn off the gas valve during the process of putting out fire.

2.3 Level 2

After player saved Sarah, Sarah tells that her sister may also be trapped in her sister's house. Player needs go to her sister's house and check her sister.

2.3.1 Level goal

There are 5 game goals in this level.1, Teach players how to put out three different kinds of fires. 2, Teach players to use the extinguisher to release smoke. Smoke inhalation is the

leading cause of death from fires [7]. 3, Teach players CPR knowledge and make players want to search professional knowledge about CPR from game's diary. The diary in game have the website link about CPR. 4, Teach players where is the safe spot to hide during an earthquake or aftershock 5, teach players that helping others during a disaster as important as protecting yourself.

2.3.2 Level flow

Player needs to use the wet towel and enter the house. The house is filled with smoke, so player should use the extinguisher that is outside the house to release the smoke. Then player can see the first floor, there is a stair in the first floor. After player goes to the second floor, an aftershock will happen. Save Sarah's sister by CPR when aftershock stops. The figure about the level flow level 2 is as following.
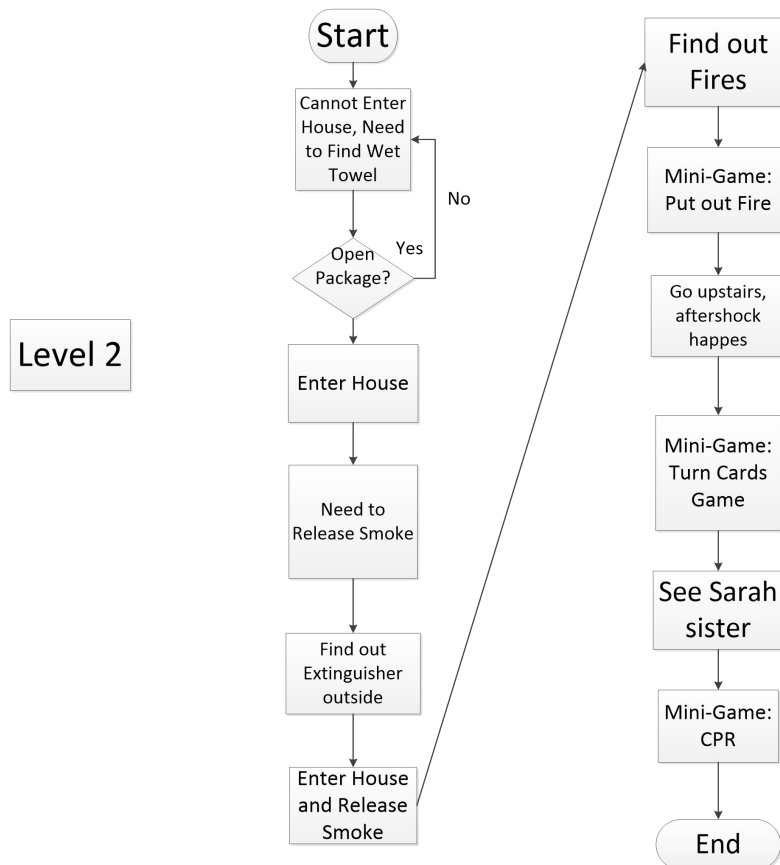

Figure 2.3.2-1: Game flow of level 2

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2.3.3 Victory condition

Players need to solve all six puzzles on the level in order to complete it.

1. Players need to find the way to enter Sarah's sister's house.

2. After entering into the house, they must find a way to put out the fire caused by electricity.

3. There is a mass of smoke in the house, players cannot see anything. So players should release the smoke by using the water.

4. Find the fire hydrant outside the house, and spray water towards the house.

5. Find the correct place to avoid danger for aftershock.

6. Save Sarah's sister.

When player finish these six puzzles sequentially, they will pass the level.

2.3.4 Gameplay design

We designed the puzzle about smoke because smoke is more dangerous than fire [8]. Smoking inhalation has more probability to cause death than fire itself [7]. Smoke also disorients people in enclosed areas, decreasing viability and inducing coughing and gagging. Most people think the best way to release the smoke from a room is to open a window, but the inrush of oxygen often reignites smoldering fires that cause more smoke and other problems. The best way to rid an area of smoke is by misting water into the air. The water droplets capture the smoke and it falls to the ground. We included a puzzle where the player must spray a smoky area in order to pass safely.

When an earthquake or aftershock happens, people who are trapped must choose the safe place for them. We give the player a number places to take shelter during the earthquake and then explain which one is best.

2.4 Mini Game: Supermarket

Player follows government instruction and go to supermarket to buy necessary items.

2.4.1 Level goal

The level goal is to let player know what items need to be bought before the earthquake. And what items are unnecessary when earthquake or aftershock comes.

2.4.2 Victory condition

There are fifteen items in total for players to choose, ten of them are correct items and five of them are wrong items. Player must choose at least eight correct items in order to win the game.

2.4.3 Game flow

When game starts, players have a cart with ten available spot. Item card will randomly pops out, and players need to choose buy or pass the item. Both correct and incorrect items will be put into the cart unless players choose to pass the item. When the number of items in cart reached ten and more than eight of items are correct, it will come to success animation. Otherwise, it will come to failure animation.
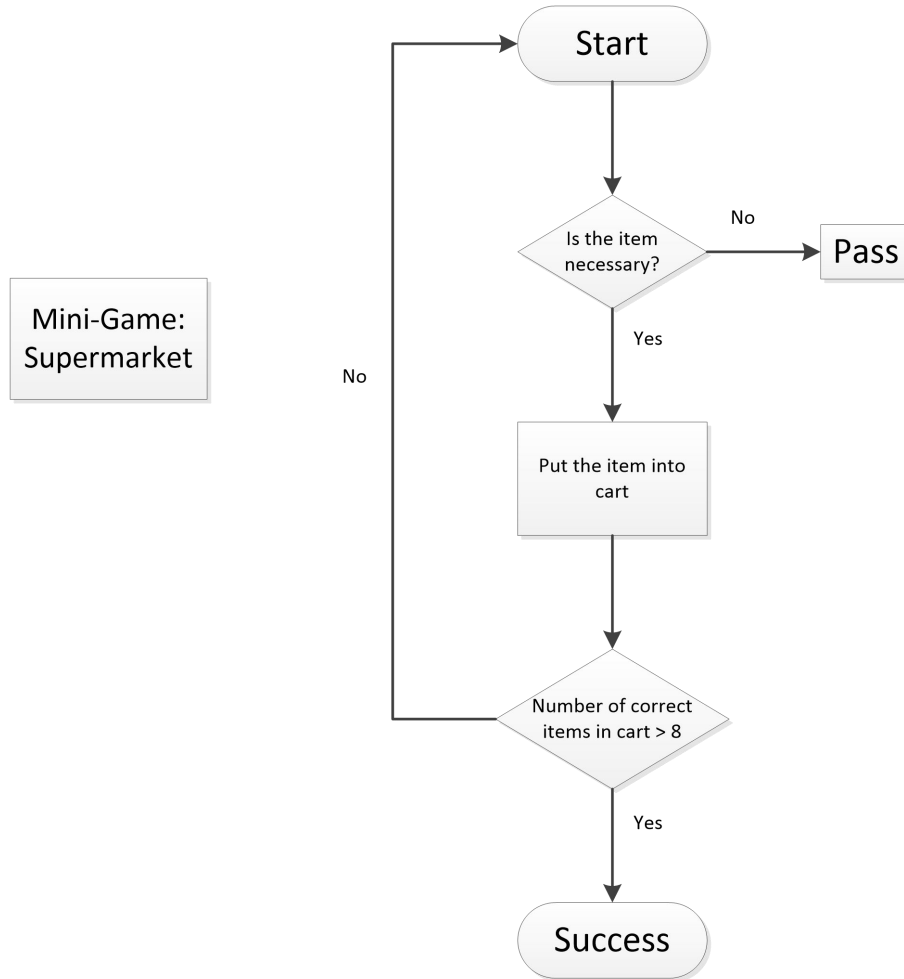
Figure 2.4.3-1: Game flow of mini game: Supermarket

2.4.4 Level design

In this level, the game will be very casual, the goal that we designed is order to make the players remember which items need to be prepared before the earthquake. So using the direct and simple way to make players judge themselves. In a general way, the memory by thinking is more eternal.

For decreasing the difficulty of this mini game, players can choose 2 wrong items. We hope that people will be confused by the choices, because "common sense" doesn't always lead to the right choices in preparing for earthquakes. Many people immediately

buy bread and milk, but they are very perishable, especially when electric service is out and refrigeration isn't available.

A list of players' choices, clearly indicating the correct and incorrect choices, is displayed at the end of the mini game.

2.5 Mini Game: Repair game

The second step of government instruction said that items or places in the house is dangerous when an earthquake coming. Player needs to check or fix necessary items in the house.

2.5.1 Level goal

This game is shows players what items or places need to be checked and repaired before the earthquake.

2.5.2 Victory condition

Players need to find 9 correct places or items totally to be repaired or checked from the whole scene.

2.5.3 Game flow

The game scene has been rolling when game starts. Players need to click the keyboard when they think it need be checked or repaired. After players find more than 8 correct places, they will pass the level. Figure 2.5.2-1 shows the game flow of the mini game of fix.
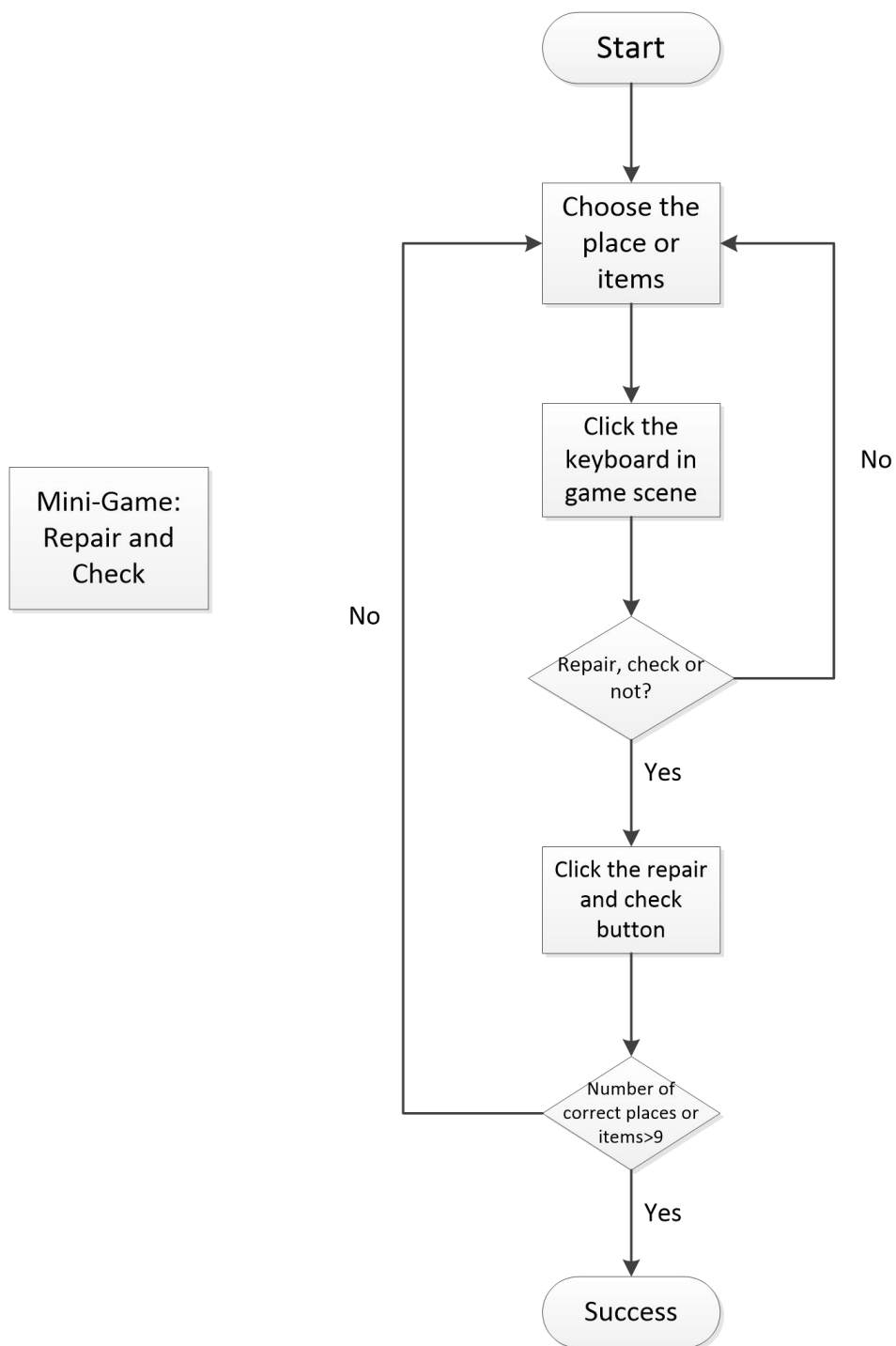
Figure 2.5.3-1: Game flow of mini game: Repair and check

2.5.4 Gameplay design

This mini game is like the market game, but there are some differences. This scenes also scrolls past, and the player chooses which items to repair or check in their house.   It is more difficult than the market game because if they don't choose to repair the area, it is gone. The market game gives the players more than one chance at each item.

2.6 Mini Game: CPR game

This mini game can teach people about basic CPR knowledge.

2.6.1 Level goal

In order to teach the player the basics of CPR, we use the song "Staying Alive," which provides the correct number of chest compressions per minute. We use a basic rhythm game mechanic where chest compressions come down a strip and the player must push a button when each beat comes across the line.

2.6.2 Victory condition

When the heart is filled with the blood, the player wins the mini game.

2.6.3 Game flow

At the first, the game starts and player should press the key following the music rhythm. Every time the players press the key right following the rhythm, there will be some blood filled into heart. After the heart is full of blood and the player wins the game.
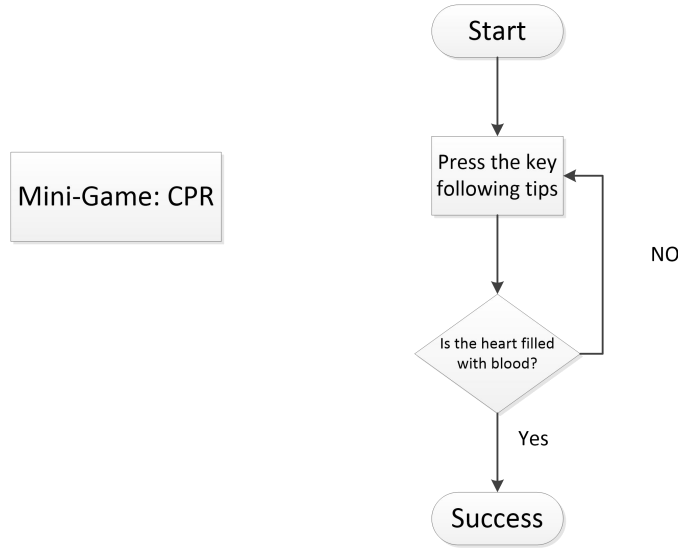
Figure 2.6.3-1: Game flow of mini game: CPR

2.6.4 Gameplay design

We made special background music for this game, the rhythm of our music is kind of like "Staying" Alive", We made the music for this section of the game because it has close to 104 beats per minute, and 100-120 chest compressions per minute are recommended by the British Heart Foundation [9] and endorsed by the Resuscitation Council (UK) [10].Our music has close to 100 beats per minute. The player has to keep up that rhythm by pressing a key in time, much like actual CPR.

There are two keys the player must press, one for compressions and one for mouth-to-mouth.

As the player succeeds, a heart on the left side of the screen slowly fills with color. When the heart is full, the player has succeeded in resuscitating the victim.

We made it clear that this mini game is no substitute for actual CPR training, and point players to where they can sign up for CPR classes in their area.

2.7 Mini Game: Turn card game

This mini game teach player where is the safe place to hide when earthquake or aftershock comes.

2.7.1 Level goal

When earthquake comes, people are always nervous and do not know what to do and where to go. In this game, we allow the players to learn when earthquake comes, what behaviors are right and what are wrong, where is safe for them and where is dangerous.

2.7.2 Game flow

At the first the game starts and the player need to choose two cards from many cards we provided. If the two cards are the same, these two cards will be turned over. If the two cards are not the same, these two cards won't be turned over. After all the cards we provided being turned over, the player wins the game.
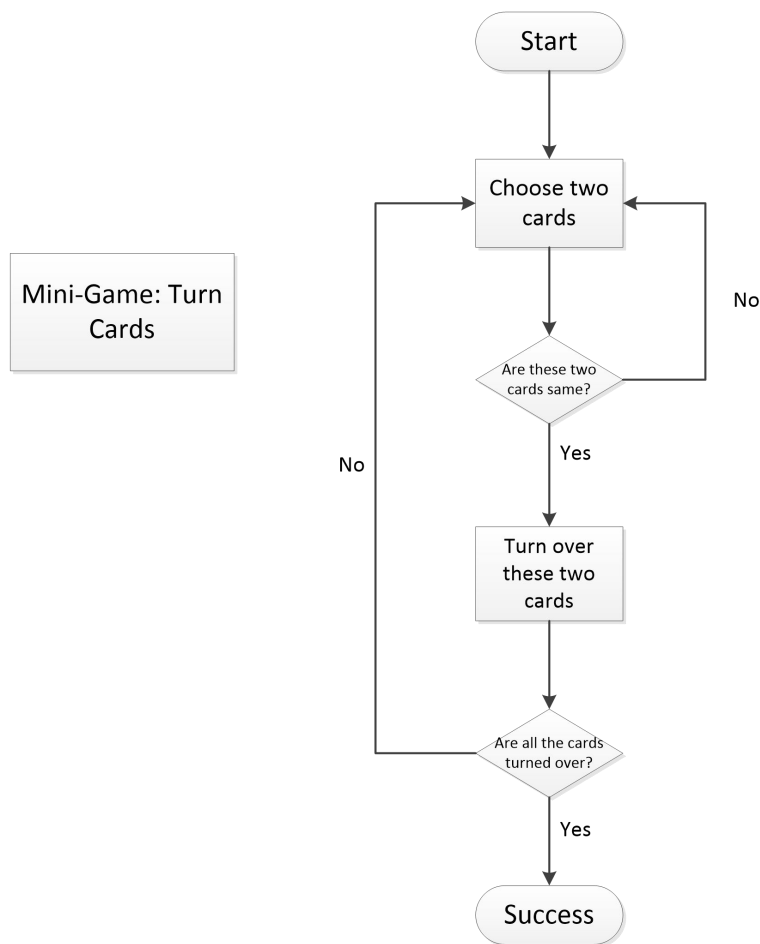
Figure 2.7.2-1: Game flow of mini game: card game

2.7.3 Victory condition

After all the cards have been turned over, the player wins the game.

2.7.4 Gameplay design

This is basically a game of Concentration, with each pair of cards showing a correct action, or an incorrect action with a line through it.   We hope that through repetition, players will internalize the correct actions in an earthquake.

We used symbols and simple iconic pictures instead of words to overcome language barriers and engage visual learners.

2.8 Mini Game: Putting out Fires

In this mini game, player need to figure out the different methods to put out fires.

2.8.1 Level Goal

This mini-game teaches players to use correct tools to put out different fires.

2.8.2 Victory Condition

Player needs to put out 5 fires with 5 tools collected in the game.

2.8.3 Game Flow

Players need choose right tool to put out the 4 different fires. For each kind of fire, player has to pick the right tool. Players win the game if they choose the right tool to put out the right kind of fire.

```
                              ┌──────────┐
                              │  Start   │
                              └────┬─────┘
                                   │
                              ┌────▼─────┐
                              │ Get Tool │◄──────┐
                              └────┬─────┘       │
  ┌──────────────┐                │             │
  │    Mini      │           ┌────▼─────┐       │
  │ Game:Putting │   No      │ Put Out  │    No │
  │  out Fire    │           │   Fire   │       │
  └──────────────┘           └────┬─────┘       │
                                  │             │
                              ┌───▼───┐         │
                              │ Are   │         │
                              │ tools │         │
                              │ left  │         │
                              └───┬───┘         │
                              Yes │             │
                              ┌───▼───┐         │
                              │ Are   │─────────┘
                              │ fires │
                              └───┬───┘
                              Yes │
                              ┌───▼───┐
                              │  End  │
                              └───────┘
```
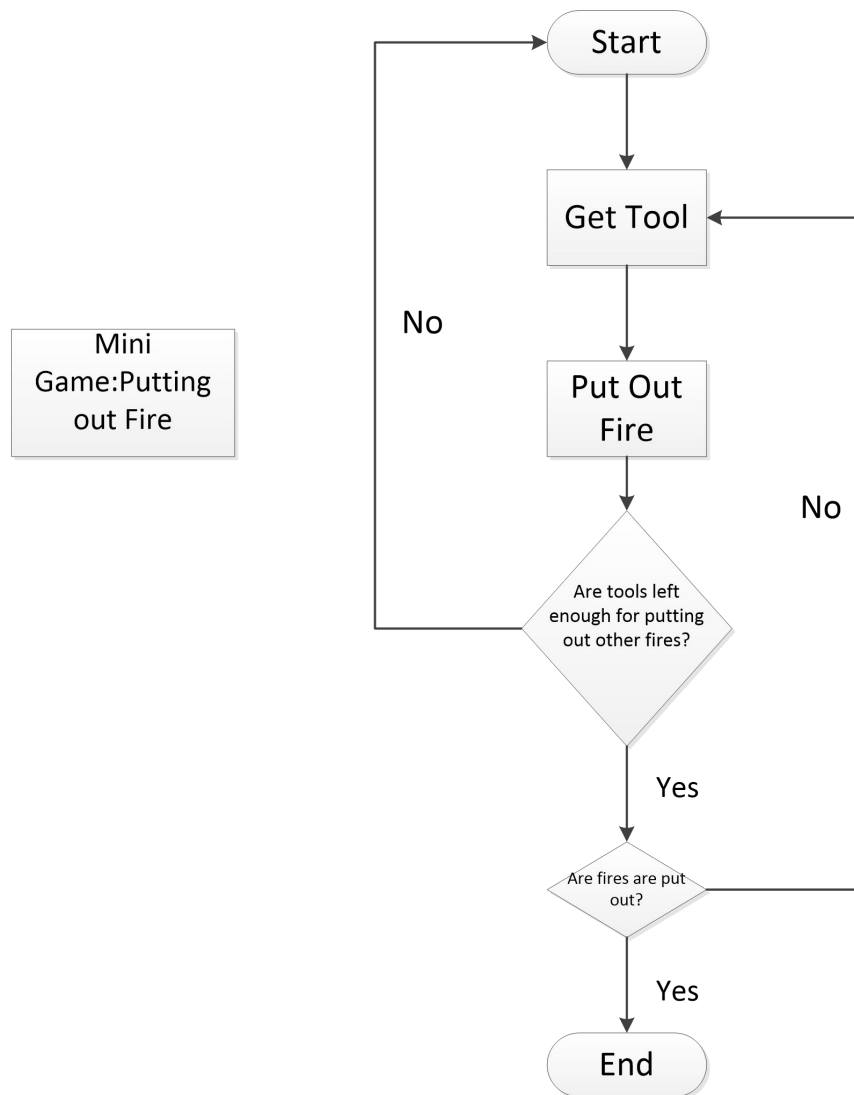
Figure 2.8.3-1: Game flow of mini game: Put out Fire

2.8.4 Gameplay Design

The player needs to collect firefighting tools (pile/soil, water, extinguisher),Which are all placed where they should be in the real world, and use them to put out the correct types of fires.– pile/soil can be collected in the garden, water can be collected in the restroom, extinguisher can be collected in the bedroom.