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Flooded - A Location-Based Game for Promoting Citizens' Flood Preparedness

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PROBLEM DESCRIPTION

With the global climate changes we can expect an increased occurrence of floods, even in areas not previously affected by flooding. Despite of this, the general public seem to be ignorant of the possibility and consequences of floods. The increased chance of flooding and the low level of public awareness illustrates the need to improve flood preparedness of citizens.

A serious game is a game that is created for a learning purpose. Studies have shown that serious games have potential to engage the public and raise awareness. By using a game, players can experience a simulated flooding scenario with the dangers that it entails, without fearing for their actual lives. A location-based game is a game where the gameplay is built around the player's real location, and has proved useful for promoting exploration of areas. This is vital to be able to teach players knowledge about specific areas where a crisis can happen. In this thesis a game design for a location-based serious game for promoting flood preparedness should be created and evaluated.

SAMMENDRAG (NORWEGIAN ABSTRACT)

Forekomsten av flom har økt de siste årene. Likevel viser undersøkelser at flomberedskapen blant befolkningen er lav. Befolkningens bevissthet rundt konsekvensene av flom er noe som må forbedres. Seriøse spill har vist seg å ha potensiale for å engasjere og å øke bevissthet.

Hovedmålet med oppgaven var å lage et design for et lokasjonsbasert, seriøst spill som kan brukes til å fremme beredskapen til befolkningen. Potensielle læringsmål, og drivere for samarbeid, utforskning og engasjement ble utforsket for å svare på oppgaven.

En analyse av lokasjonsbaserte spill ble sammen med teori om flomhåndtering og flomberedskap brukt som grunnlag for et spilldesign. Spilldesignet ble brukt som veiledning under utviklingen av en prototype, som ble evaluert med tre grupper spillere.

Arbeidet resulterte i en prototype for et lokasjonsbasert, seriøst spill for Android, kalt Flooded, der spillere kan bevege seg rundt i lokalmiljøet og gjøre oppdrag som er tilknyttet ekte flomscenarier. Spillet sikter på å bevisstgjøre spillere i forhold til farene og konsekvensene ved flom, og fremmer samarbeid og utforskning for å lære bort kunnskap om områder og samarbeidsferdigheter, som er nyttige verktøy i en flomsituasjon. Motivasjonsdrivere som belønning, leaderboard og tidspres er brukt for å skape en engasjerende spillopplevelse.

Ti retningslinjer for design som kan veilede fremtidig utvikling av lokasjonsbaserte spill for flomberedskap ble laget. Retningslinjene fremhever viktigheten ved å ta høyde for brukbarhet og GPS-problemer, og understreker spillelement som bør integreres i et spill i en flomberedskapskontekst, slik som utforskning, samarbeid, engasjement og bevisstgjøring.

Abstract

The occurrence of floods have increased in recent years. Despite of this, studies have shown a low level of flood preparedness among citizens. The public's lack of awareness of the consequences of floods is something that needs to be improved. Serious games have been shown to have the potential to engage the public and raise awareness.

The main objective of this thesis was to create a design for a location-based serious game that can be used to promote citizens' flood preparedness. Potential learning goals and drivers for collaboration, exploration and engagement were explored to accomplish the objective.

An analysis of location-based games, and theory of flood management and preparedness were used as a basis for the game design. The game design was used to guide the development of a prototype, which was evaluated with three groups of players to determine the game's engagement and learning potential.

The work resulted in a prototype for a location-based serious game for Android, called Flooded, where players can move around in their local environment and complete quests that are connected to real flooding scenarios. The game aims to sensitize the players to the dangers and consequences of flooding and promotes exploration and collaboration, to teach knowledge of the territory and collaboration skills, which are useful tools in a flooding situation. Motivational drivers such as rewards, a leaderboard and time pressure were used to create an engaging gameplay experience.

Ten design guidelines were created that can guide future development of location-based games for flood preparedness. The guidelines highlights the importance of addressing usability and GPS issues, and underlines elements that a game in the context of flood preparedness should contain, such as exploration, collaboration, engagement and sensitization

PREFACE

This thesis is submitted to the Norwegian University of Science and Technology for partial fulfillment of the requirements for a master's degree. This work has been performed at the Department of Computer and Information Science, NTNU, Trondheim, with Monica Divitini and Ines Di Loreto as supervisors.

I would like to thank my supervisors for their helpful input and guidance throughout the project. Without their invaluable feedback, this thesis would not have been possible.

I would also like to thank the participants that volunteered to evaluate my game. At last, I would like to thank Preben Mannsverk for lending his Photoshop expertise to help me create icons for the user interface.

Trondheim, June 18, 2013

Sondre Johan Mannsverk

CONTENTS

Preface	i
Contents	iii
List of Figures	vii
List of Tables	ix
1 Introduction	1
1.1 Problem Definition	1
1.2 Research Domain	3
1.3 Research Questions	3
1.4 Research Method	5
1.5 Outline of the Report	7
2 From a Player’s Perspective	9
2.1 General description	9
2.2 Quests	10
3 Problem Elaboration	13
3.1 Flood Preparedness	13
3.2 Serious Games	14
3.3 Location-based Games	15
3.4 High-level Requirements	16
4 Related Work	19
4.1 Selection of Games	19

4.2	Geocaching	20
4.3	Frequency 1550	24
4.4	Floracaching	28
4.5	Savannah	30
4.6	Shadow Cities	32
4.7	The Hidden Park	33
4.8	Implications for my work	34
5	Game Design	39
5.1	Game Description	39
5.2	Phases	41
5.3	Quests	42
5.4	User Interface	51
6	Technical Description	63
6.1	Technological Choices	64
7	First Iteration	69
7.1	Status of the application	69
7.2	Evaluation Settings	69
7.3	Results	78
7.4	Implications for design	83
8	Second Iteration	85
8.1	Status of the application	85
8.2	Results	85
8.3	Implications for design	96
9	Third Iteration	97
9.1	Status of the application	97
9.2	Results	99
10	Discussion	109
10.1	Usability and Technical Issues	109
10.2	Sub RQ-1	113
10.3	Sub RQ-2	118
10.4	Sub RQ-3	119
10.5	Sub RQ-4	122
10.6	Main RQ	123

11 Conclusion	127
11.1 Summary	127
11.2 Contributions	128
11.3 Reflection on the Work	128
11.4 Future Work	129
Bibliography	131
I Appendices	137
A Additional Design Documentation	139
A.1 Requirements	139
A.2 Features of Flooded	141
A.3 Reward System	142
B Algorithms	145
B.1 Checking to see if a Player is in the Flood	145
B.2 Compute the Distance Between the River and the Sandbag . .	146
C Detailed Technical Description	149
C.1 Activities	149
C.2 Activity Diagram	149
C.3 Facebook Implementation	150
C.4 Google Maps Implementation	151
C.5 Implementation of Quests	151
C.6 GCM Implementation	152
C.7 Additional Classes	153
C.8 Client/Server Communication	154

LIST OF FIGURES

1.1	Research Domain	3
2.1	Map of the Game Area	10
2.2	User Interface	11
4.1	The CATERAN Trail GeoTour	21
4.2	Map of medieval Amsterdam © Waag Society	25
5.1	A person playing the game	40
5.2	Flood Protection-quest	45
5.3	Measuring Points	48
5.4	Evacuation Zone	50
5.5	Search and Rescue-quest	53
5.6	Welcome screen	54
5.7	Main menu	54
5.8	The Map	55
5.9	No more sandbags	55
5.10	User Interface	56
5.11	Message Dialog	58
5.12	User Interface	58
5.13	Player is dead	60
5.14	Player is revived	60
5.15	Leaderboard	60
5.16	Player profile	60
5.17	List of friends	61
5.18	Inbox	61
7.1	The old User Interface	70

7.2	A view of the river	71
7.3	Map of the Game Area	72
7.4	Quest Area With Crates	72
7.5	Measuring Points	73
7.6	Evacuation Zone	74
7.7	Search Zones	75
7.8	A Maximum Impact Flood	76
7.9	A player walking along Nidelven	78
7.10	Meanwhile, on the opposite side of the river	79
7.11	The players' sandbag placement during the first evaluation	79
7.12	"I wonder if I can use this to get more sandbags"	80
8.1	The players' sandbag placement during the second evaluation	87
8.2	The players' movement during the second evaluation	91
8.3	A player walking into a dead end	92
9.1	The players' sandbag placement during the final evaluation	100
9.2	The players' movement during the final evaluation	104
C.1	Activity diagram	150

LIST OF TABLES

4.1	Summary of Location-based Games	35
4.2	Collaboration - Useful Qualities and Features	35
4.3	Collaboration - Useful Qualities and Features	36
4.4	Engagement - Useful Qualities and Features	37
4.5	Technical - Things to consider	38
5.1	Summary of Quest Goals	52
5.2	Map markers	57
5.3	Quest Actions	57
A.1	Learning Requirements	140
A.2	Engagement Requirements	140
A.3	Technical Requirements	141
A.4	Summary of Quest Rewards	143
A.5	Summary of Level System	143

CHAPTER 1

INTRODUCTION

The aim of this thesis is to look at how one can promote the flood preparedness of citizens. The next sections of this chapter describe the context and background of the project, as well as the motivation behind it. The research questions and research method are also described. The final section gives a brief outline of the content of the report.

1.1 Problem Definition

Flooding causes enormous damages all over the world every year. In the period 1975-2001, flood events killed over 175,000 persons and affected more than 2.2 billion persons. [Jonkman, 2005] In addition to loss of lives, flooding causes material damage of billions of US dollars every year. [Kundzewicz and Jun, 2004]

While writing this thesis, a significant flood affected Central Europe, as well as Norway. In the German city of Passau, it was the worst flood in 500 years. [Hengst, 2013] As of writing, the Danube river is expected to reach record levels in Budapest. [ATPN, 2013]

Managing flooding and the risk of flooding is key to reduce loss of material damages and lives. To manage and reduce flood risks, a variety of strategies are used. Forecasting and warning is used to predict when a flood is coming and to let the public know that they need to prepare. The construction of flood protection is important to reduce the impact of an impending flood, and involves building dams and levees and other protective measures. [Middelkoop et al., 2004]

A key element of flood management is the use of volunteers to help with

flood protection. [Suzuki, 2006, Shrubsole, 2000] To recruit volunteers the public needs to be aware that flood preparedness require citizen participation. A major issue in this regard is that people will only prepare if they feel that it is personally relevant. [Terpstra, 2010]

With the global climate changes we can expect an increased occurrence of floods, even in areas not previously affected by flooding. [Eggen and Urquhart, 2013] Recent studies on Dutch citizens' intentions in flood preparations from 2010, showed that general awareness of flood consequences and the importance of flood preparedness was low. [Terpstra, 2010] Only a minority of the respondents believed a flood would be likely within the next decade, and people had in general little fear of any potential consequences. In addition, they seemed unaware that they have a personal responsibility in flood preparedness. The general public seem to be ignorant of the possibility and consequences of a major flood, and few considers moving away from areas that could be affected by flooding, with many seemingly displaying a "*This cannot happen to me*"-attitude. [Krasovskaia et al., 2001]

The increased chance of flooding, the severe consequences of major floods and the low level of awareness of citizens makes it clear that there is a need to improve the flood preparedness of citizens. [Takao et al., 2004] This thesis investigates the use of a location-based serious game to see if it can be useful in this regard.

A serious game is a game that is created for a learning purpose. The advantage of using a game or game-like mechanics, is that people associate games with fun. A person would rather spend time doing something that they enjoy, instead of boring, tedious work. By using game mechanics such as level advancement, badges and leaderboards, engagement can be increased even further. The players does not need to know that they are learning if it is abstracted correctly. A person is more likely to be engaged in learning if he is playing a game than through paper-based learning. [Dede, 2009] Another useful characteristic of games is that they "*allow the participants to immerse themselves in a realistic simulated setting without the fear of real life consequences.*" [Ebner and Holzinger, 2007] In the context of flooding, this means that the players can experience a simulated flooding scenario with the dangers that it entails, without fearing for their actual lives.

A location-based game is a game where the gameplay is built around the player's real location. [Nicklas et al., 2001] Promoting exploration is vital to be able to teach players knowledge about specific areas where a crisis can happen. [Mora et al.] A location-based game provide a low-cost and flexible solution for promoting exploration, as it can easily be extended to any area.

1.2 Research Domain

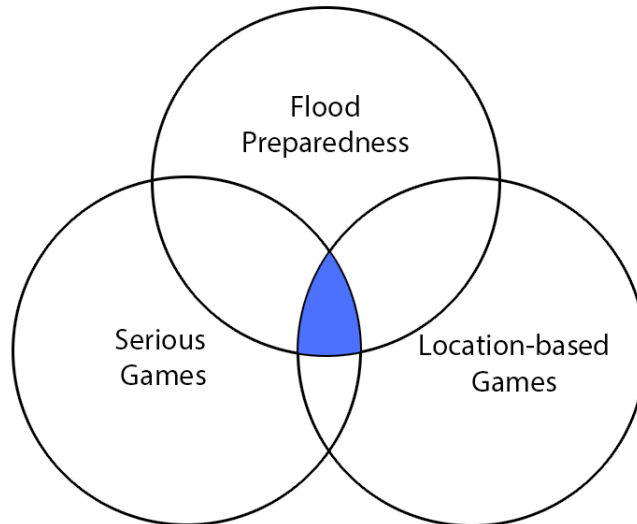


Figure 1.1: Research Domain

Figure 1.1 shows the research domain of the thesis. The goal was to design and implement a prototype for a location-based serious game that promotes citizens' flood preparedness. To accomplish this the fields of flood preparedness, serious games and location-based games had to be combined. The motivation for doing so is explored in the Problem Elaboration-chapter.

1.3 Research Questions

1.3.1 Main Research Question

The main research question is:

- How can one design a game that promotes citizens' flood preparedness?

The first step to promoting flood preparedness is to sensitize citizens to the dangers and consequences of a flood. To accomplish this the game should put the players in realistic flood and flood management scenarios. There are several qualities that are useful for flood preparedness, such as knowledge of the territory and collaboration skills. A game in this context should provide the necessary tools to promote and improve these qualities. To have any lasting appeal the game needs to be engaging, both to retain learning and

to make people want to return to play. The balance between learning and engagement has to be right, though. To help answer the research question I have created four sub-questions.

1.3.2 Sub-Questions

- Sub RQ 1: What can such a game teach the players in terms of flood preparedness?

A key to flood preparedness is being aware of the dangers of a flood. If you know how dangerous a flood can be, it is more likely that you understand the consequences of not acting correctly. It is also important to know what the correct action is when a flood warning is given. Awareness of how to manage a flood is useful for protecting your own property, but also for knowing how you can help the local government.

A vital part of understanding the risks of a flood event is to have knowledge of ones local area. As an example, by knowing what the river looks like «normally», people can be more aware when the water level has increased, and possibly predict that a flood is imminent. In an evacuation scenario, knowing where it is safe to go is important. For a location-based game to be effective in teaching this knowledge, the players must be given objectives that allow for, and preferably encourages, exploration of their local environment.

The goal of this research question is to look at the learning outcome of the game in terms of flood and local area awareness, and find out what the game can teach the players.

- Sub RQ 2: Which mechanisms can be used to improve collaboration skills?

Collaboration is important in a flood situation, both between the local government and the public, and for coordination during flood management. When the local government issues a flood warning for an area, the people living there must be able to comprehend the severity of the situation and take the necessary precautions in terms of protecting their homes and evacuating in time.

Flood protection, such as sandbag placements and building of levees, has to be organized and executed with good coordination. As volunteers are used extensively in flood management, they need to have the necessary collaboration skills to be able to contribute effectively. The goal is to identify mechanisms that are useful for increasing collaboration skills in the context of flooding.

For a game to be successful in this regard, it needs to have objectives where the success of an individual depends on the group's success. It also needs to incorporate the needed communication tools required to collaborate effectively.

- Sub RQ 3: What is the right balance between fun and learning?

For a serious game to be effective in promoting flood preparedness, it should present them with somewhat realistic scenarios. Common strategies to manage a flood includes flood protection and territory monitoring. The game should put them in situations where they can mimic these strategies and see the impact of their actions.

It is important though that the game offers the right balance between learning and fun. A major pitfall in serious game development is putting too much emphasis on one or the other, which could result in a serious game with no learning value or a serious game that no one would want to play.

- Sub RQ 4: Which mechanisms can be used to promote engagement?

The main purpose of a serious game is to train or educate users. But if the game is not engaging, users would not want to return to play, highly diminishing it's impact. The goal is to identify mechanisms that can create engagement in a serious game in the context of flooding. It is especially interesting to look at how the fact that the game is location-based affect the engagement, both positively and negatively.

A location-based game is influenced by a variety of external factors that can affect the level of fun. For example, weather conditions, GPS-inaccuracies in certain areas, traffic noise and «outsiders» disturbing the game. On the other hand, a location-based game offers a different experience to conventional games, in the sense that the gameplay takes place in the real world. Players get to be outside and play, running around instead of sitting at a desk or on a sofa.

1.4 Research Method

To answer the research questions, an iterative development process with three iterations was used. The process led to the creation of a prototype of a location-based serious game for Android, which was evaluated with users in regards to the research questions. The prototype was based on work done in a previous project. An analysis of location-based game, and theory in the context of flood management and preparedness were used to guide the game design.

1.4.1 Previous Work

The work in this thesis builds upon the work done in the course TDT4501 Computer Science, Specialization Project at NTNU during the Fall of 2012. The goal of that project was to create a design for a serious game that promoted crowdsourcing in the context of crisis management. The result was a game design that aimed to promote crowdsourcing in the context of flood management. A prototype of a location-based serious game for Android was created as a proof-of-concept. The prototype was not evaluated with users, but it was clear that it needed work before it could be utilized to promote crowdsourcing.

When starting to write this thesis, I made the decision to change the focus towards promoting flood preparedness. The reason was that I felt the potential for using a location-based serious game for this purpose, was greater than for promoting crowdsourcing. The core of the previous prototype was used as a foundation for the prototype developed in this thesis, but the game design was altered to fit with the new context.

1.4.2 Development Process

In the first phase of this project, the prototype was improved gradually, initially focusing on technical features and improvements. The prototype was tested with a few users to see if it performed sufficiently in an actual gameplay environment.

In the second phase, the focus was on adding content to the game. To facilitate good game dynamics that was both engaging and had learning potential, an analysis of location-based games was performed. Theory of flood management and flood preparedness was looked at to facilitate realistic scenarios. Three new quests were added to the game, while the quest from the initial prototype was adapted to fit with the new context.

The game went through three iterations of development and evaluation. The results of each evaluation were used to guide the development of the the next iteration.

The evaluations included a game session where the users played the game. The players were given questionnaires where the aim was to survey their opinion on the game's level of fun and usefulness in terms of promoting flood preparedness. A focus group was held after each game session to get more in depth feedback from the players. The results of all the evaluations were used to analyze the game's strengths and weaknesses in terms of the research questions.

1.5 Outline of the Report

This section describes the organization of the report. The report is implicitly split into five parts. The first part contains the introduction and a look at the game from a player's perspective. The second part contains the problem elaboration and a chapter on related work, which was used as a foundation when creating the design for my game. The third part contains the game design and the technical description. The fourth part contains three chapters that corresponds to the three iterations and evaluations of the game. The fifth part contains the discussion and the conclusion, which has a section on future work.

CHAPTER 2

FROM A PLAYER'S PERSPECTIVE

In this chapter I introduce Flooded, the location-based game that was developed for this thesis. The chapter will give an insight into what the game is about and how the game is played. The focus will be on how the game is viewed from a player's perspective. The learning output of the game will not be looked at, as this is explored in Chapter 5.

2.1 General description

Flooded is a collaborative location-based serious game, which was created to promote citizens' flood preparedness. The game can be played in any area, but for the evaluation it was set up to be played in a specific area of Trondheim, which is shown in Figure 7.3. The game can be adapted to be played with any number of players, but at least three players are recommended, if not, the collaborative and social aspect is lost.

In the game, you take upon the role of a volunteer who is told by the government that a flood is coming. You first have to go through basic training to be allowed to help. Before the flood arrives, you and other volunteers have to build flood protection and measure the water level. When a flood warning is given, you need to evacuate the area, and after the flood has hit, you have to search for missing persons while avoid being taken by the flood waters. Each of these scenarios are represented by quests. An explanation of each quest is given in Section 2.2.

The primary interaction with the game is through a map interface. The map displays your position, the game objects and objectives, and the position of other players. You use the map to navigate, and buttons on the screen to



Figure 2.1: Map of the Game Area

interact with the game. As the game is location-based, you have to physically move around in the area to interact with the game. Information is presented through message dialogs and text displays. Figure 2.2 shows what the map interface looks like.

You need to work together with other players to be successful. Collaboration is supported by a messaging functionality, which allows you to send and receive textual messages within the game. You can also communicate face-to-face and use the position of other players to determine the correct strategy.

The game uses a reward and level system as motivational drivers. When doing correct actions in the game, you are given points. If you do incorrect actions, you lose points. By gaining enough points you are promoted to a higher rank. A leaderboard displays an overview of the best players.

2.2 Quests

The game is quest-based and contains four quests with different objectives. Three of the quests are multi-player quests and contains global objectives, which means that when another player completes an objective it is completed

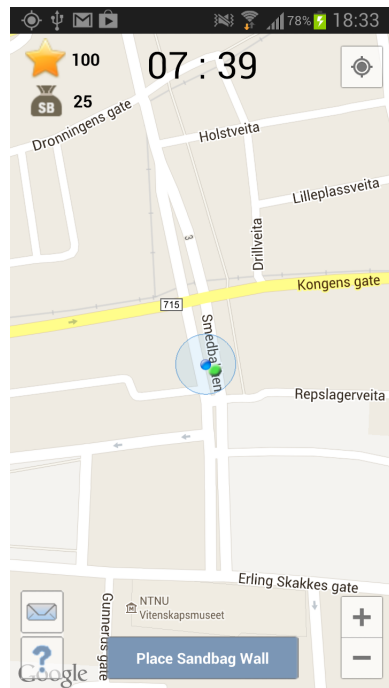


Figure 2.2: User Interface

for you as well. Whether you achieve success in the quests or not are determined by the actions of all the players. The fourth quest is a single-player quest.

When you the game for the first time, you have to go through a short tutorial. After completing the tutorial, the first quest is introduced. All the quests have a time limit. When the time runs out for a quest, the next quest starts automatically. When the last quest is finished, the game ends and you are given a summary of how it went.

2.2.1 Tutorial

The tutorial introduces you to the background of the game. You are told that a flood is coming and that the government needs volunteers to help manage it. You are given three tasks that you have to perform, which will teach you the required skills to be a volunteer. First you have to interact with a crate, which gives you five sandbags. Then you have to place a sandbag wall at a location of your choice. Finally, you have to send a message to another person in the game. By completing the tutorial, you are given some points and is promoted to the rank of novice volunteer.

2.2.2 Flood Protection

At the beginning of the quest, you are told that you can help mitigate the impact of the flood by placing sandbag walls. You are not told where it is smart to place them. The challenge is to find out where to place the sandbag walls and to decide who goes where. If everyone places their sandbag walls at the same location, only parts of the area will be protected.

2.2.3 Monitor Territory

As the water has been rising, the government wants to find out if the river is close to its critical level. When the water reaches that level, the river will overflow, causing a flood. You are told to measure the water level at five different points along the river. You do this by walking to the points and interacting with them. If you discover a critical rise in water level, you need start an evacuation.

2.2.4 Evacuation

You are told that the flood is coming and that you need to get out of the area as fast as possible. You need to get to the evacuation zone on the map before the time runs out. If you fail to reach the zone in time, you will die. Dying leads to a short suspension from the game and a small loss of points.

2.2.5 Search and Rescue

The flood has hit the area, and you are told that a group of people have gone missing. If you walk into the flood you die. The map contains a number of zones that you have to search in. Each zone contains a missing person. After finding the person, you have to interact with him and find out his condition, which can be dead, injured or dehydrated. You then have to notify the government of your findings. Yours and the other volunteers' common goal is to find all the missing persons before the time runs out. Coordinating who goes where is key to be able to cover all the zones.

CHAPTER 3

PROBLEM ELABORATION

In this chapter, the problem defined in the introduction is elaborated upon. A set of high level requirements that needed to be supported were identified.

3.1 Flood Preparedness

Flood preparedness is used to describe any precautionary measures taken against impending flood(s). To increase the preparedness of citizens the most effective strategy is to inform them of the consequences of a flood. The citizens must be sensitized to the dangers of flooding and the importance of flood management. They also need to be aware of the need for volunteers in flood preparedness work, such as the placement of sandbags. [Terpstra, 2010]

Awareness of appropriate action to take in the event of a flood warning is vital. [Burningham et al., 2008] A key here is knowing where and when to evacuate. To know where to evacuate the citizens must be aware of their local area. They need to know where it is safe to go and how to get there.

For a citizen to be effectively prepared for a flood he needs to have the required collaboration skills. [Pooley et al., 2010, Schaafstal et al., 2001] This includes listening and correctly responding to flood warnings, and communicating effectively when helping with flood management.

3.2 Serious Games

Vast amount of literature has been written on the subject of serious games and their usefulness in terms of learning. [Susi et al., 2007, Bonus] Some of the advantages were described in Section 2.2. Here I will elaborate by looking at serious games created to promote crisis management, to see what makes them useful. I will also discuss the importance of balancing the fun aspect and the learning aspect.

3.2.1 Balancing Fun and Learning

A key challenge for serious games is to balance fun versus learning. An excerpt from [Huynh-Kim-Bang et al., 2010] illustrates the challenge: *"From our interviews with KTM-Advance, our partner firm, we noticed a typical type of problem: one game designer provided game goals that would be unlikely to match the pedagogical objectives while the customer insisted on inserting fifty pages taken from a technical guide into the Serious Game. Doing this would more than likely destroy all the fun."*

This does not mean that a game can be too fun or too useful in terms of learning, but that if one of the elements overshadow the other it can create an unintended experience for the players.

3.2.2 Related Serious Games

No serious games were found that aimed to promote flood preparedness, but a couple were found in the context of flood management, FloodSim and Levee Patroller. FloodSim is a simulation developed to help raise awareness of the flooding issue surrounding flood policy, while Levee Patroller is a game developed to train professionals the required skills to inspect levees.

FloodSim is a relatively short and simple simulation, with basic game elements that allowed the players to make strategic decisions in the context of flood management. The gameplay is linked to the territory, in the sense that the players can see an overview of a simulated flood in different cities in the UK, but it does not allow the players to actually explore the territories. It had no collaborative elements, but the potential of collaborative play were hinted at as a future improvement, as it would allow players to *"make collaborative and maybe localized decisions"*. [Rebolledo-Mendez et al., 2009] The results of the evaluation of FloodSim, showed that the game was successful in increasing awareness at the basic level, which suggests that serious games such as FloodSim have potential to engage the public and raise awareness. [Rebolledo-Mendez et al., 2009]

Levee Patroller aimed to train the appropriate inspection skills. The motivation for creating the game was that failures of levees are quite rare, which made it difficult for the "levee patrollers" to learn from experience. A game was therefore created to simulate levee failure, to teach the patrollers to detect them. A case-study of Levee Patroller showed that the game was useful in promoting flood defence, as *"these games provide compelling, authentic, and safe environments and give its users experience.* The study also stated that: *"Games should be thought of as a way for people to experiment with measures (and evaluate them), to practice rare and unexpected situations, and to bring awareness."* [Harteveld, 2008]

In a paper on collaborative serious games for crisis management, ten serious games in the context of crisis management were analyzed. [Di Loreto et al., 2012] The paper stated that for crisis management games, giving the players limited time for decision-making is key. It underlined the importance of considering local optimum and global optimum, that the best local decision is not necessarily the best global decision. The use of communication and collaboration in crisis management games was also looked at, and the need for a debriefing activity was identified. Although the games that were looked at aimed to facilitate crisis management and not promote flood preparedness, several of the findings are interesting for a game in the context of flood preparedness as well. One of the main findings identified in the paper was that the games had a limited link with an actual territory, as I have stated previously, this is important to support for games in the context of a crisis. [Mora et al.] None of the games were location-based, which could explain the reason for this limitation.

3.3 Location-based Games

As I wanted to create a game that could facilitate the exploration of the territory, I decided to make my game location-based. Location-based games have been created both for learning purposes and for engagement purposes. In this section I focus on the learning aspect, and explain why using a location-based game is a good idea for my thesis.

3.3.1 Mobile Technology and Games

The use of smartphones have increased significantly the last few years. [on-bile.com, 2012] The technological advances have equipped mobile devices with GPS receivers and good processing capabilities, and the improvement of mobile networks have reduced latency considerably. The technology of

mobile devices combined with GPS allow for the creation of location-based games. [Nicklas et al., 2001]

A location-based game is a game where the geographical location of the player is a key game element. [Schlieder et al., 2006] That means that the game world is a combination of physical and virtual space. When a player moves in the real world he also moves in the game world.

Potential for Learning

Location-based games have been created both for entertainment and serious purposes. In a review of mobile location-based games for learning, most of the games were role-playing games that allowed the users to play realistic roles within a physical space. The learning potential was *“related to the strong interconnection between the narrative supported by the virtual world and the physical action.”* [Avouris and Yiannoutsou, 2012] By connecting the physical space of the real world with virtual game entities, one can create an immersive learning experience.

Location-based games allow the players to learn from a different viewpoint, as they have elements of social, experiential, and situated learning. [e Silva and Delacruz, 2006, Avouris and Yiannoutsou, 2012] In the context of a serious game for flood preparedness, the nature of such games can allow for the learning of collaboration skills. They offer a natural link to real territories. This can allow the players to explore and increase the awareness of their local area. By placing the game area near a river, the players can imagine how it would be if a flood hit the area in real life. You can push realistic scenarios on the players that are connected to real life situations, such as evacuating from the area. The players would then have to physically run to be able to evacuate, creating a more immersive and engaging experience than if they were playing a regular game.

You could create a desktop-based game that could more realistically depict a flood, but implementing such a simulation would be costly and not to mention very difficult. A location-based game provides a low-cost, flexible solution that can easily be adapted to new areas.

3.4 High-level Requirements

The previous sections of this chapter describes theory on flood preparedness, social games and location-based games. From the theory I identified several elements that a game should have to be useful in promoting flood preparedness. I picked five of the elements as the high-level requirements for my game,

which can be viewed below. Sensitization, realism and exploration are linked with **Sub RQ-1**, collaboration with **Sub-R2**, realism and engagement with **Sub-RQ3** and engagement with **Sub-RQ4**.

3.4.1 Sensitization

The first step to promoting flood preparedness is to sensitize citizens to the dangers and consequences of a flood. If a person understands the dangers of a flood, he is more likely to understand the importance of flood management. The game should sensitize the players to the dangers of flooding, the importance of flood protection and territory monitoring, and increase their awareness of the correct behaviour when a flood warning is given.

3.4.2 Realism

The game should place the players in a situation that mimics a real life flood. As it is a game, it is impossible to create a completely realistic experience, but it should contain realistic elements.

The players should get a feeling of stress while playing the game, similarly to how it would be in a real flood. It is important, though, that the stress is not too high as this could demotivate the players from playing. As the main goal of the players is to manage the flood, it is important that the actions they perform in the game makes sense in terms of real life flood management.

3.4.3 Collaboration

In flood management, collaboration is key for coordinating relief work. It is also vital that citizens cooperate with the government when a flood warning is given. Both cases require the citizens to have the necessary collaboration skills.

In a learning sense, the advantage of having collaborative tasks instead of individual tasks is that people working in groups can capitalize on each others' resources and skills. They can construct new knowledge through the social interaction, or increase their common knowledge by sharing a mutual understanding. Collaborative tasks can also have an effect on the general enjoyment of doing the task, as it facilitates a more social experience.

3.4.4 Exploration

Exploration of the territory can enable players to learn more about their local area. This is key in terms of flood preparedness. With knowledge of the local

area people know how to get around, which can be crucial in an evacuation scenario.

3.4.5 Engagement

The main purpose of a serious game is to train or educate people. But if the game is not engaging, people would not want to return to play, highly diminishing its impact. It can also lead to people learning less when playing the game, as they have less motivation to do well.

Note that there is a clear distinction between fun and engagement. When playing a game, the player often has to go through tedious tasks that are not necessarily fun. Such tasks are performed because he knows there is a payoff for doing them. If the player is motivated to do the task, he is engaged in the activity. As such, the game should feature engaging gameplay, but it does not need to be fun.

CHAPTER 4

RELATED WORK

This chapter contains my analysis of location-based games. I look at three games created for ludic purposes and three games created for serious purposes. At the end I summarize my findings and identify any implications for my work. To drive the analysis I use the high-level requirements identified in the Problem Elaboration. In the analysis, collaboration, engagement and learning are the main talking points. In terms of the high-level requirements, learning comprise sensitization, exploration and realism. For the serious location-based games I will mainly look at how learning was enabled, note that none of these games have the same learning goal as a game for flood preparedness.

4.1 Selection of Games

When doing research for the related work, only one location-based game was found in the context of crisis management, Code Red: Mobile, but as it was poorly documented in terms of game dynamics and mechanics, it was not investigated. No true location-based games were found in the context of flood preparedness or management.

When selecting games to analyse I narrowed down the candidates from over 20 to six. The games were found by using previously written state-of-the-arts [Avouris and Yiannoutsou, 2012], by searching on the internet and from previous knowledge of existing location-based games.

Geocaching was selected as it is the most well-known location-based game. I was especially interested in how the game promoted exploration. Flo-racaching was selected as it had similar dynamics to Geocaching, but with

a specific learning goal. Frequency 1550 was selected as it combined exploration in a city environment with learning. Savannah was selected as it was the one of the most cited location-based games. Shadow Cities was selected as it was the location-based game I found that most closely resembled a "regular" game, that is a game created for entertainment purposes. The Hidden Park was primarily selected because it featured a editor for expanding the game to new areas, which could be useful for a game for promoting flood preparedness as well.

In the analysis I will first describe each game, before I discuss them in terms of learning, engagement and collaboration. Note that not all of the games have all three aspects. Other interesting aspects of the games will also be highlighted. At the end of the chapter the games are summarized and the implications for my game design is identified.

4.2 Geocaching

According to [Sherman, 2004], geocaching is an outdoor game where the players hide and locate containers, like a treasure hunt where the players use GPS. Although geocaching is not a mobile game per se, I felt it had many interesting features worth exploring. The largest Geocache listings site geocaching.com describes Geocaching as follows: *"Geocaching is a free real-world outdoor treasure hunt. Players try to locate hidden containers, called geocaches, using a smartphone or GPS and can then share their experiences online."*

The definition of a geocache is a hidden container that is linked with a geographical location. For the cache to be useable in the geocaching game, it has to contain a logbook where players can log their find. The game is played on different web sites where geocachers register caches for others to find, log their findings and report problems with caches, such as water damage to the log book.

An interesting feature of geocaching is that it is the players themselves that create the game. The creation of content is actually a part of the game itself. This is a limitation in the sense that some areas may have no geocaches if there are no people that have played in that area. It is also a strength because it means that the game will continue to grow if people are actively contributing. The creation of new geocaches offers the players new challenges and more areas to explore.

4.2.1 Collaboration

Although geocaching does not require the players to collaborate, players often meet to search for caches together. This makes the game a social experience, which can increase the players' motivation. As locating a geocache requires the participants to search for and find a physical object, working together makes the game easier. [Vitale et al., 2012] shows that geocaching can help increase the cooperative skills of the participants. One participant reflected on the learning experience of working with another person: *"As we were working with our partner to reach an ultimate goal, we had to make decisions together along the way. If one of us was wrong, we were both wrong, and this activity allowed us to develop skills for cooperative learning."* The participants felt they were able to develop the required team-work skills necessary to find caches successfully.

4.2.2 Learning

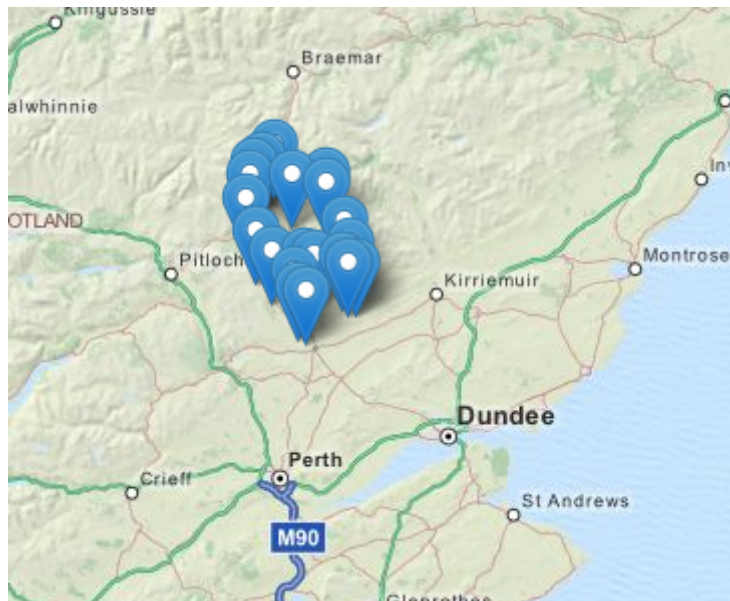


Figure 4.1: The Cateran Trail GeoTour

An inherent feature of Geocaching is exploration of new areas. How much the players get to explore is dependent on their motivation, as well as the placement of geocaches. Some geocachers only go for easily accessible caches, while others actively explore new areas when they play. Geocachers often hide geocaches in locations that they want others to discover, this could

be a statue, a beautiful spot in nature or other areas they think could be interesting for others. The game has the potential to increase the participants knowledge of the territory they are playing in.

geocaching.com offers custom tours, coined GeoTours, that are created to introduce players to new locations. The GeoTours contain a set of geocaches that the player must collect to complete the tour. This pushes the players to explore more of the area. The site also provides the geocachers with the opportunity to create their own GeoTours that they can share with others. Some GeoTours are connected with historic events to teach the players the history of an area. An example is the CATERAN Trail GeoTour, which is located in Scotland. See Figure 4.1 for a map of the GeoTour.

In addition to pushing exploration, geocaching introduces players to geolocations and teaches players to navigate using a map and GPS functionality. Some geocaches require the players to solve logical puzzles, while others are placed at locations with historic significance. The game can also promote conservation of nature and collaboration.

Physical Exercise

Geocaching can motivate people to exercise as it gives them an extrinsic motivation to go outside. Some geocaches are located in easily accessible places, such as a city park, while others require long hikes to reach. The amount of exercise you get depends on how often you play, and on which geocaches you decide to search for. Even if you only go for the "easy" geocaches, you will need to physically move to collect them.

4.2.3 Engagement

"Understanding Geocaching Practices and Motivations" by Kenton O'hara presents a field study of everyday geocaching behaviour. Among his findings were the different motivations people had for participating in the game. The motivating factors he identified are listed below. [O'Hara, 2008]

- Social Walking
- Discovering and Exploring Places
- Collecting
- Profile and statistics
- First to find: competition and urgency

- Challenge: individual and social aspects

The participants in the study stated that geocaching gave walking a sense of purpose. The game created an opportunity for them to go on a walk. This is best illustrated by a comment made by one of the geocachers: *"I doubt I would stop at the bottom of the hill and think – oh I'll go for a walk up there. It's not likely but when you think there is a cache up there I would do it. My incentive is that cache at the top of the hill."*

Geocaching also helped people discover new places, both in unknown and known areas. One participant used the game as a tool for exploration, he used it to find out more about new areas. It also helped several of the participants to discover places they never knew existed in their local area.

For many of the participants, their motivation came from "collecting" caches. After finding a cache they would post it on the geocaching web site. The web site keeps a record of all the caches a person has found. This acted as achievements that increased the engagement of the participants and motivated them to continue to participate.

On the geocaching.com web site, the participants can visit each others profiles. The profiles show where a person lives, all the caches he has placed and all the caches he has found. This added an extra value to collecting caches as the participants were able to display their achievements to others.

An interesting observation was that players were competing to be the first to find newly placed caches. Being the first to find a cache became a behavioural driver for continued participation, as players wanted to get the kudos for being first.

An important motivating factor for many of the participants were the different challenges provided by geocaching. Some geocaches required them to solve puzzles, while others required them to scuba dive or climb. The fact that geocaching provides suitable challenges for everyone and that even children can participate is an important driver for participation.

Varying level of difficulty

Each geocache is registered with a difficulty rating and a terrain rating, which describes how challenging it is to find it. Both are given a number between 1 and 5, where 1 is easiest and 5 is hardest.

The difficulty rating can correspond to the length of the hike to the cache, how well the cache is hidden or if you have to solve a puzzle before you can find the cache.

The terrain rating includes the amount of slope, the footing, the nature of the trail and if you need any special equipment or training to retrieve the cache, such as scuba diving gear. [Sherman, 2004]

The game offers a natural progression, as players can start by finding easy caches and move on to more difficult ones as they get more comfortable with the GPS technology and the nature of the game.

4.2.4 Summary

The features and qualities of geocaching that are most interesting to integrate into a serious game in the context of flood preparedness are listed below.

- Pushes players to exercise
- Pushes players to explore new areas
- Improvement of collaboration skills
- Objectives with varying level of difficulty
- Achievements and statistics

4.3 Frequency 1550

Frequency 1550 is a mobile, serious location-based game developed for learning purposes. The game was developed as a research pilot by the Waag Society with the aim of increasing the players' awareness and knowledge of history, and their motivation for history. The contents of this section is based on the evaluation of the game, which was documented in [Huizenga et al., 2009] and [Admiraal et al., 2011]. The research was conducted with 458 pupils, aged between 12 and 16 years, from 20 classes from five schools. 10 of the classes played the game whereas the other 10 received a regular history lesson. The goal of the evaluation was to determine if a game could be effective in teaching history to pupils.

Frequency 1550 is a game that turns Amsterdam into a medieval playground. The game takes place in six areas that represents Amsterdam anno 1550, as can be seen in Figure 4.2. The areas represent six different themes from medieval times. Each theme is introduced using videos that are sent to the mobile devices when the players enters the corresponding area. The video clips use sounds of medieval activities and presents clues to the players, which lead them towards a hidden location that contains assignments. The players are assigned to one of the areas at the beginning of the game, and the identity of either a beggar or a merchant. After completing the assignments in one area they can move to the next one.



Figure 4.2: Map of medieval Amsterdam © Waag Society

The players were divided into groups of four students each, with two walking the streets with mobile devices and the two other located at the evaluation headquarters on desktop computers. The goal of the players using the desktop computers was to coordinate the actions of the moving players and help with solving tasks. They can follow the players by using their GPS data, which they can use to help guide the players, and they can use the internet to search for information. The goal of the mobile players were to physically move from location to location and solve tasks.

When a player reaches a particular locations, he is given three video assignments: an orientation assignment, an imagination assignment and a symbolic assignment. Each assignment has three parts and ends with a multiple choice or question which requires the players to combine their knowledge. The assignments are solved by a combination of creating or selecting photos, answering questions, recording video and searching for details on buildings. At the end of playing, the teams gathered for a debriefing to see who did best and to reflect on the gameplay experience, including the media they produced during the game.

4.3.1 Collaboration

Frequency 1550 utilizes collaboration as a tool to increase the learning potential of the players. The players at the desktop computers had access to a map

of medieval Amsterdam, as well as a map of present Amsterdam. They could also view the videos at the same time as the "street walkers" and search for information on the internet. The players walking the streets had only access to the medieval map. Because the players had access to a different level of information, it meant that the players had to cooperate to achieve success.

4.3.2 Learning

The results of the evaluation showed that there were no differences in level of motivation for the subject of History in general or the topic of the Middle Ages between the pupils playing the game and the pupils that received a regular lesson. On the other hand, the results showed that, in general, playing the game was better than regular lessons for teaching the pupils more about medieval Amsterdam. This is presumably because the information was presented in a more realistic context with a connection to real locations, and because the players had to actively learn by playing the game.

The game pushes exploration by utilizing real buildings and landmarks. The players had to actively move from location to location, and in symbolic assignments they had to search for specific details on buildings. This allows the players to learn about the history of buildings in Amsterdam.

Engagement

The game utilizes a combination of collaboration and competition as motivational drivers. Players collaborated to solve assignments. A simple reward system was used as an extrinsic motivation, where the players would gain points for every assignment they completed. Although the main goal of the players is to collaborate in completing assignments, there is an underlying goal to get a better score than the other groups. Competition is used to push the players to do their best. To add to the competition, the players can confront other players in hopes of stealing points of them. The winner of the confrontation is decided by using the players' order, with merchants beating beggars. A team member can also drop virtual medieval rats on the other team which causes their screens to go black for a short period of time. The results showed that the game engaged the players, but that technical issues were a significant detrimental factor.

4.3.3 Technical and Other Issues

The three main issues identified from the results were presenting information, latency issues and GPS issues. The participants focused more on the

gameplay than the background information. They would barely watch the videos that presented this information and did not read the text messages very well. One reason was the small screen size of the devices in combination with sun glare, another reason was that the players were more focused on completing assignments and gaining points. *"Participants' little attention to video and text messages illustrated their focus on playing the game, and their lack of focus on the historical narrative embedded in these messages."* [Huizenga et al., 2009]

A different issue with the information flow was that the students were not always told if they were merchants or beggars. This caused some of the competitiveness of the game to disappear, as they had no idea of who won a confrontation.

The most obvious issues identified were the technical issues. The GPS would routinely show the wrong position of the players or fail to show any position at all. In addition to the GPS issues, sending photos and videos took a very long time. The issues caused a loss of engagement. As stated by [Huizenga et al., 2009]: *"Technical failures were clearly observed to be responsible for many instances of disengaged behaviour throughout the study days. In future research, more and earlier tests of technology should be performed in order to prevent technical failures to intervene with learning and motivational effects."*

4.3.4 Summary

Frequency 1550 has several interesting features that could be included in a game for promoting flood preparedness. The pilot study of the game also highlighted a number of issues worth considering. Some useful features of the game in the context of my work:

- Pushes players to explore new areas
- Connects learning with real locations
- Asymmetric information
- Group versus group competition

Some considerations that should be taken:

- Importance of precise information presentation
- Latency of media sharing
- GPS-issues

4.4 Floracaching

Floracaching¹ is a game, similar to geocaching, where the players search for plants identified by a GPS coordinate. The game was created as an extension of BudBurst Mobile, a mobile application that was developed as a record-keeping tool for Project Budburst.² Project Budburst is a citizen science program that uses volunteers for recording the life stages of plants.

Players use a mobile device with GPS capabilities to find floracaches placed in real world locations. A floracache is a plant linked with a GPS coordinate, a description and an image. Players can also create game content by making floracaches that others can find. This is done by making a report of a plant with their mobile device and then creating a floracache for it on the floracaching.org web site, the hub for the game.

4.4.1 Learning

Floracaching is a gamification of data gathering, in the sense that it uses game elements to engage players beyond the extrinsic motivation of helping scientists. The players gain points for recording plant life cycle information that Project Budburst uses to help understand environmental change. The purpose of creating the game was for "motivating data collection and increasing user retention". Han, Graham, Vassallo, and Estrin

The evaluation of the game indicated that the game was also useful for teaching the players about plant life in their local area. [Han et al.] In addition, the game can teach the players GPS navigation skills and place recognition.

As the game requires players to actively move around to search for plants, it has the potential for pushing them to explore an area. A limitation for this game in this regard is the lack of participants, the floracaching.org web site has of 10.06.2013 only 33 active participants listed and just 68 floracaches created.

4.4.2 Engagement

The game uses a point-based system to drive engagement. The web site for the game has a leaderboard that lists the top five players according to their points. In addition to using a leaderboard and points for engaging the players, several other mechanics are utilized.

¹<http://floracaching.org>

²<http://budburst.org>

The floracache search-objective has three different levels of difficulty: mapped, directions and description. Mapped shows a map the players can use to navigate and grants the players 1 point upon completion. In Directions, the players must use a compass and the distance to the floracache, and grants 5 points upon completion. Description only gives the player a description of the location and grants the player 10 points upon finding the cache.

Players get badges for progressing in the game, which act as achievements that can be collected. There are a total of 18 badges in the game. One example is the Creator badge: *"Create 2 floracaches"*. Badges give the players an extra incentive for doing certain tasks.

The players also have four different ranks that corresponds to their progress. When they reach a certain number of points they are automatically promoted to the next rank.

The player's points are used to determine if he is allowed to make floracaches. Every player is given three "free" floracaches, but after that they need a minimum of 50 points to place a cache. After making a floracache, the player's username will display at the top as the creator of the cache.

On the floracaching.org web site every player profile is listed. A player profile displays a player's badges, completed objectives, rank and points. This gives the player an extra motivation to do well, as they can display their success in the game to anyone visiting their profile.

4.4.3 Technical Issues

The players need to be within 10 meters of a floracache to interact with it. The inaccuracy of GPS positions can sometimes cause the players to be unable to interact with the cache though. As a way of coping with these issues, the Floracaching game utilizes a manual solution for players to adjust their location on a map. [Graham et al., 2012] This lets the players move their position inside a 30 meter radius of the displayed GPS position. The new position is then used to check if the players are in range of the floracache.

Summary

Interesting features:

- Pushes players to collect and submit real data
- Potential for pushing players to explore new areas
- Objectives with varying level of difficulty

- Leaderboard
- Badges, ranks and player profile

Floracaching proposed a solution for managing GPS issues:

- Adjusting locations to reduce impact of GPS errors

4.5 Savannah

Savannah is a location-based game prototype designed to teach players about lion behaviour. The aim of the developers was to learn more about how one could design a game that was both engaging and had a learning purpose. [Facer et al., 2004] The game is played with the combination of a hand-held computer and a GPS receiver, rather than with a mobile phone.

In Savannah, the players act the role of lions in a savannah. During the evaluation of the game, groups of five players played together as a pride of lions. [Benford et al., 2004] Their goal was to carry out a series of missions where they would mimic real lion behaviour. An important note is that the game rules are improvised by observers outside of the game. That is, the observers decided if the players actions inside the game were successful or not, instead of having this functionality built into the game.

After completing a mission, the players would go inside to reflect on what they had done. A facilitator would help them reflect and give them instructions for their next mission. The players was also be able to see a replay of their movements and actions in the game.

4.5.1 Collaboration

The game was designed to encourage player collaboration. Collaboration was supported by having missions that required several players to act together at the same time, for example to hunt an animal. As the boundary of the game limited the playing area to a school playing field, the players could easily communicate with each other using words and gestures. This allowed the players to easily coordinate their actions within the game.

4.5.2 Learning

The main goal of the game was to teach the players about lion behaviour. To facilitate this the players were given two missions, one where they would mark the territory and one where they would hunt.

Marking of the territory was used to teach the players that maintaining the pride's territory is an important task of a male-lion. In the game this was accomplished by having the players map their territory by patrolling and scent-marking.

The second mission was used to teach the players about the difficulties of hunting and that scavenging already dead animals is a smart way of getting food. A key here was to teach them that bringing down some prey requires several lions, while some animals, such as elephants, are impossible to kill.

The game sessions that were conducted in the evaluation clearly separated between immersion inside the game and reflection during the debriefing. This was done to increase the learning potential. By having a separate debriefing session the players could better reflect on their actions in the game. If the game session did not have a debriefing, some of the knowledge might have been lost. [Benford et al., 2004]

A beneficial effect of playing the game is that you are exercising while playing. As an example, you have to physically run away from virtual elephants to survive in the game.

4.5.3 Engagement

For the players to be engaged by the game it required them to be immersed in the experience of being a lion. This was supported by presenting sights and smells as images on the screen, and sounds through the headphones. The game contained several virtual threats to the players' lives, to create a feeling of danger.

4.5.4 Summary

Interesting features:

- Pushes players to exercise
- Designed for collaboration
- Debriefing session for added reflection
- Added immersion through images and audio

4.6 Shadow Cities

Shadow Cities is a location-based multiplayer game for iPhone.³ The game is created purely for entertainment purposes and has many similarities with desktop-based massively multiplayer online role-playing games (MMORPGS), such as World of Warcraft.⁴

In Shadow Cities, players turn into mages with magical powers, and their neighborhood turn into a magical game world. The players' goal is to explore and conquer their city and other cities all over the world. When starting the game, the players decide between two opposing factions, the Animators and the Architects. The players battle enemy mages, destroy structures, complete missions and conquer gateways to achieve success in the game. It contains many traditional staples of role-playing games, such as levels, spells, mana, health and player-versus-player (PvP) combat.

4.6.1 Collaboration

A key part of achieving success in Shadow Cities is collaborating with other players of your faction. The process of collaboration is facilitated by having a friends list enabled by Facebook Connect. The players' friends list is populated by their Facebook friends that have the game. Having friends makes it easier to collaborate and coordinate when attempting to take control over neighborhoods. Private chat channels are available that enables communication. Players can also jump to locations of their friends, even if they are located in other cities.

4.6.2 Learning

Although Shadow Cities is a game created for fun, it has a slight learning aspect in terms of exploration of to the territory. The game world in Shadow Cities is a reflection of the real world. Moving in the real world makes you move in the game. The game utilizes real maps and your real location, but the game elements are randomly generated. The nature of the game pushes you to physically around your area, but the lack of connection to real structures and landmarks diminishes the exploration aspect. Another issue in terms of promoting exploration, is that you are able to teleport to other areas, such as New York City, using beacons. When a player does this he is no longer using the real world to navigate in the game, but simply using his own movement to traverse the virtual space.

³<http://www.shadowcities.com/>

⁴<http://eu.battle.net/wow/>

4.6.3 Engagement

As Shadow Cities is a game in the traditional sense, the gameplay is designed to be as engaging as possible. The main driver for engagement is the collaborative PvP campaigns, where the players work together and battle against the other faction to take control over a neighborhood.

The factions compete in weekly campaigns where the goal is to gather the most energy. Energy is gained by completing missions, capturing spirits, taking control of gateways and other activities in the game. Players can also battle opposing mages. Winning a campaign grants the winners medals that act as achievements.

Players will also level up as they play the game, giving them access to new spells and more power. This is a traditional role-playing game dynamic that can increase player participation. An in-game leaderboard is used to track the best players.

4.6.4 Summary

Interesting features:

- Leaderboard
- Level system that allow players to increase their powers
- Achievements
- Facebook-enabled friends list
- Communication through chat and private messages
- Group-based collaboration and competition

4.7 The Hidden Park

The Hidden Park is a location-based game developed for iPhone. The game is designed with families in mind and aims to get children playing outdoors. [hid]

The game turns local parks into fantasy worlds where the players must run around to solve puzzles using clues. It utilizes the iPhone's GPS, camera and speaker to immerse the players into the game world. The goal of the players is to prove the existence of magical animals in the park, to stop it from being over-run by greedy developers.

4.7.1 Learning

A key goal of the game is to push children to go outside and play in the park. As the players has to physically move to reach locations in the game it means that they get exercise while they play. A secondary goal is to teach the players the importance of preserving natural beauty of parks.

The players follow an interactive map containing game objectives linked with GPS coordinates. The game triggers animations and tasks as the players reach waypoints in the park. The players can get to know their local parks by playing the game, but a limitation is that it is only available in a select number of parks. To remedy this the developers have created a "park editor" that players can use to extend the game to new parks around the world.

4.7.2 Engagement

The game features an interactive fantasy world with puzzle-solving and a story-driven approach suited for children. To immerse the players, the camera functionality of the iPhone is used to combine the real world and the fantasy world of the game. When a player takes a photo, fantasy creatures automatically appear in the photo. The background and instructions of the game is given through a fictional phone call with a character named Trutton.

4.7.3 Summary

Interesting features and qualities:

- Pushes players to exercise
- Pushes players to explore
- Players can extend the game to new areas
- Added immersion through images and audio

4.8 Implications for my work

The summative table shows the different aspects the games. It is important to note that this table does not take into the account the level of engagement, learning or collaboration in the games, but whether they are supported in one way or another or not. The learning goals of the games differ from each other, and from the learning goals of a game for flood preparedness. Some of the games support exploration, which can improve the players' knowledge of

Game	Collaboration	Learning	Engagement
Geocaching	X	X	X
Frequency 1550	X	X	X
Floracaching		X	X
Savannah		X	X
Shadow Cities	X		X
The Hidden Park		X	X

Table 4.1: Summary of Location-based Games

Feature
Push collaboration
Communication through chat and private messages
Facebook-enabled friends list
Group-based collaboration and competition
Improvement of collaboration skills
Asymmetric information

Table 4.2: Collaboration - Useful Qualities and Features

the territory, and collaboration, which can improve the players' collaboration skills.

From the six games I identified a list of features, qualities and considerations that could be useful for a location-based game in the context of flood preparedness. My findings are summarized in this chapter. Some of the features overlap, for example for both learning and engagement. The information was used when deciding which feature and qualities my game should have, and what considerations I needed to take. A selection was made when creating the requirements for the game design, which are described in Appendix A.1.

4.8.1 Collaboration

As explained in the introduction, supporting collaboration is key in a game in the context of flood preparedness. The game has to give the players objectives that require them to collaborate in one way or another.

To make collaboration in a game possible, the players must be provided with a way of communicating, especially if they are not physically located at

Feature
Improvement of collaboration skills
Push players to explore new areas
Push players to exercise
Push players to collect and submit real data
Connects learning with real locations
Precise presentation of information

Table 4.3: Collaboration - Useful Qualities and Features

the same place. Communication functionality can be very useful in a serious game in the context of flood preparedness.

Having a friends list that is connected to a player's Facebook friends makes it easier to find people to play with. This functionality can also be used to increase a game's popularity by letting players share the game through Facebook.

If a game is aiming to improve the collaboration skills of the players, it should offer them objectives where collaboration is necessary, either implicitly or explicitly. Collaboration can also be used as a motivational driver and to support group-based learning. Group-versus-group gameplay can be a motivational driver for players as it urges both competition and collaboration.

If the players have access to different levels of information it requires them to share information to be successful. The sharing of information and the players' collective knowledge can be used as a problem-solving tool. Asymmetric information is transferable to a crisis scenario, where citizens, coordinators and relief workers all have access to different level of information.

4.8.2 Learning

As I have stated in the previous chapters, increasing knowledge of the territory is an important step in promoting flood preparedness. To achieve this, the game needs to push the players to explore the area. Connecting real locations with factual information can increase the learning potential.

In the context of a flood preparedness game, pushing people to move around the area can increase their stamina, which is beneficial if a flash flood warning requires a quick evacuation by foot. Although this is not the main objective of my game, it would be interesting to see if it can have this effect on the players.

A debriefing session can give the players a chance to reflect on their game experience. Having a debriefing could be very beneficial in facilitating re-

Feature
Leaderboard and Player Profile
Achievements and Badges
Level system and Ranks
Objectives with varying level of difficulty
Group-based collaboration and competition

Table 4.4: Engagement - Useful Qualities and Features

taining and gaining of knowledge among the players.

Collecting and submitting data is an important part of crowdsourcing in the context of crisis management. Integrating game objectives based on collection of data could be useful in a game that promotes flood preparedness as well, because using volunteers for data collection is an integral part of real flood management, especially in developing countries. [Neussner, 2009]

Presenting information through videos and messages on a small screen can cause the player to miss all or parts of the information. This is especially true when the sun is causing a glare on the screen. All information that the players need to play the game as intended should be given. If not, the players could miss out on some interesting aspects of the game, or play in an unintended way.

4.8.3 Engagement

Having achievements can be useful for enticing people to participate. Presenting statistics let players display their success to others, which can motivate them to do well in the game. Leaderboards, badges, ranks, achievements and player profiles can all be used to increase engagement and participation in a serious game. While leaderboards push competition, the others can act as a form of self-motivation, as it gives the players goals to achieve within the game.

If a game offers objectives with different difficulty levels it becomes more accessible to novice players, without removing the challenge that adept players need for motivation. In addition, giving the players the option of gradually moving on to more difficult tasks can be a driver for continued participation.

Collaboration can be used as a motivational driver and to support group-based learning. Group-versus-group gameplay can be a motivational driver for players as it urges both competition and collaboration.

Consideration
GPS-issues
Latency of media sharing
Adjusting locations to reduce impact of GPS errors

Table 4.5: Technical - Things to consider

4.8.4 Technical

Sending videos or photos over a mobile network can cause latency issues. If the game requires real time interaction, this is a significant problem.

Issues with GPS can cause frustration and be detrimental to the game-play experience. Requiring very precise GPS locations can hinder gameplay considerably.

As GPS-issues is a very common occurrence with location-based games, any mechanic that can mitigate their impact can be useful. It is important, though, that this mechanic do not create unintended gameplay, such as cheating, or disrupt the realism of the game in a way that causes the players to lose immersion and potential for learning.

CHAPTER 5

GAME DESIGN

In this chapter, my game design is presented. The basic functionality of the game and the user interface is described with the use of screenshots from the prototype. The main features of the game can be found in Appendix A.2. The related work on location-based games was used together with the high-level requirements to create three sets of additional requirements, one for learning, one for engagement and one for technical requirements. They were used to guide the design, and can be found in Appendix A.1. Note that I only selected the ones I deemed to be most important, as it would be impossible to support all in the time constraints of the thesis. I also added other features and qualities that I felt would be useful. A screenshot from a game session can be seen in Figure 5.1.

5.1 Game Description

This section will describe the overall game dynamics and goals of the game. The players are placed in a situation where they must cooperate to manage an impending flood. The game can be set up in any area in the world through manual configuration.

The game is played on a mobile device with a clean and easy to learn user interface. The game is connected to Facebook as it has a built-in friends functionality, which facilitates a more social experience, and as such the players need a Facebook account to play. As the game is played on a mobile with interaction with a global map, the players need to have a smart phone with a connection to the internet.



Figure 5.1: A person playing the game

5.1.1 Target Group

The target group of the game is primarily students from the age of 10 to the age of 18, who are living in areas where flooding could occur. As some of the game objectives require the players to move fast from one location to another, the players need to be able to run or at least walk quickly. The advantage of this is that it creates a more realistic experience. The disadvantage is that people with movement disabilities or who are out of shape will not be able to play the game as fully intended.

5.1.2 Game Dynamics

Flooded is a location-based mobile game to be played in the player's local environment. The game world is the real world with virtual objects that the players can interact with. Players can view a map, which contains the game world, the player's position, game objects and the position of other players.

The game features four different quests that are pushed on the players. Each quest has a time-limit and certain objectives. Three of four quests allow the players to collaborate to achieve a common goal. These are all

global quests, in the sense that the players all interact with the same game world and have the same objectives. The quests are explained in detail in Section 5.3.

New players must go through a short tutorial to learn how to use the game interface before they can try the quests. This is done to ensure that the players are able use the interface as intended without major issues, as well as to help introduce the background of the game.

The game has two different phases, before the flood and after the flood. Three of the quests are in the before-phase. The phases, and their purpose, are explained in 5.2.

To help drive players to play a reward system is used. The game uses a level system where the players receive experience points for doing quests. A leaderboard shows how they are doing compared to other players. The reward system is described in Appendix A.3. The game also has a messaging functionality for facilitating communication between the players.

5.2 Phases

The game features two phases of a flood. The first phase represents the time just before a flood is about to hit, while the second phase represents the time after the flood has hit. Note that "after the flood" in this context does not mean that the flood is over, it means that the river has overflowed and that the flood water has affected the area. During the flood is a passive phase for the players as once the flood hits, they do not have the possibility to stop it.

The reason for having two phases is that it helps creating a more immersive gameplay experience. The player will get to help manage and predict the flood before it hits, and can see what happens when a flood occurs. Having two phases adds to the realism, and possibly makes the game more engaging due to the added immersion.

5.2.1 Before the Flood

In the time before a flood hits, the key is to try to reduce the impact of the flood. In the Flood protection-quest the players must collaborate to place sandbags at key locations to protect the area. The effort of the players will directly influence the severity of the flood is in the after-phase.

Before a river overflows, it is important that people in the area leave and go to a safe location. An early warning can give people the chance they need to evacuate in time. In the Monitor territory-quest the goal of the players is to measure the water at certain points near the river. If they come across a

critical rise of water, they must notify the other players and start an early evacuation.

In the last quest in the before-phase the players must evacuate to a safe zone before the time runs out. The players will have more time if they were able to get an early warning from the previous quest. If the player is unable to reach the zone in time, he dies.

5.2.2 After the Flood

When the flood hits, the river will overflow. The player will see this on the map as a transparent blue color that broadens the actual river. How much the river overflows is decided by how well the players were able to place sandbags. If a player walks into a flooded zone, he will die.

After the flood, one of the most important goals of the local government is to get help to people that are still in the area. In the Search and Rescue-quest the players will look for missing people by traversing search zones.

5.3 Quests

This section will describe each quest in detail, as well as the introductory Tutorial. The quests' goals, rules, components is explored. Each quest has three goals: the learning goal, the engagement goal and the collaboration goal.

The learning goal describes how the quest enables sensitization and exploration. Each quest presents the players with a simulated flood scenario.

The engagement goal explains how each quest tries to create an engaging experience, while the collaboration goal, if there is any, explains how the players must collaborate to achieve success. The goals for each quest are summarized in Table 5.1.

5.3.1 Tutorial

The tutorial acts as an introduction to the game. The background of the game is presented and some simple tasks are pushed on the players. The main goal of the tutorial is to familiarize the players with the interface, making sure that they are not wasting time trying to understand how to do things when they get to the quests. Each task is introduced by a short description that explains what action they must do to complete it, as well as some information on why doing it useful. The player must complete the three tasks listed below, before he is taken to the first quest.

1. Pick up sandbags
2. Place sandbag wall
3. Send message to a friend

The first two tasks are taken from the Flood protection-quest, which is the first quest the players encounter after completing the tutorial. The main reason for having a tutorial is to give the players the required knowledge to perform actions in the game without having to think explicitly on how to do them. When the players reach the Flood protection-quest they should not wonder how they pick up sandbags or how they place sandbag walls, but rather how they can effectively use their time and resources to be successful. The tutorial attempts to put the players through a natural progression from knowing nothing about the game, to having the required knowledge to perform game-related actions.

After picking up sandbags and placing them, the players must send a message to a friend. The reason the messaging functionality is introduced in the tutorial, is that it could be an important collaboration tool for the players later in the game. If it is not introduced at this stage they might not discover that it exists, or be afraid to use it, due to not knowing how to send messages. After sending the message, the tutorial is complete, and the players are given points that leads them to get promoted to the level of "Novice Volunteer". This will make the players aware that there is a point and level system in the game, which will hopefully give the players an extra motivation to do well. When the tutorial is complete the players are taken to the first quest of the game.

5.3.2 Flood Protection

In areas with a history of flooding it is vital to protect the area to minimize the damage of impending floods. [Kundzewicz and Takeuchi, 1999] As described in the problem elaboration, placing sandbags can help in this regard. In this quest, players work together to protect their area against flooding.

Learning Goal

In this quest the players will learn that placing sandbags is a suitable strategy for flood protection. The goal is not to learn what a good sandbag placement is, but that flood protection is important to reduce the damages of a flood. Because the size of the flood is decided by the player's performance in this quest, they will get to see the consequences of good or poor flood protection,

depending on how they do. The players can look at the flood on the other side of the river, where the flood will hit in full force regardless of their performance, and compare it to the side they protected. The players need to cover a significant section of the river with sandbags, which means that they will have to traverse the area. This can lead them to getting to know the territory better.

Engagement Goal

This quest combines collaboration and play in a real environment to try to create an immersive and compelling experience. It enables item sharing and the ability to see who has contributed the most. The players will need to manage their collective resources in a time efficient manner to be successful. After placing a sandbag they get to see how many points they get, and after the quest is complete they are presented with the score for the entire group.

Collaboration Goal

To protect an area against a flood, players have to cooperate. To achieve success in this quest, the players have to cover critical sections of the river with sandbag walls. Each player does not have enough sandbags to do this alone. They need to cover the entire area to the best of their possibilities, and will have to coordinate who goes where. If everyone goes to the same area they will not be successful.

Communication between the players can be face-to-face or through the messaging functionality in the game. The players can also share sandbags with their friends, which is useful if one of the players have used up all his sandbags, but is the only player in a section of the area that still needs more sandbag walls.

Rules

Players can place sandbag walls wherever they want inside the quest's boundary. Players start with twenty five sandbags, but they can receive more as gifts, or by picking them up from a crate. Placing a sandbag wall costs five sandbags, while emptying a crate replenishes five sandbags. When a player place a sandbag wall, the map is updated for all players. The goal of the players is to use their sandbags effectively to protect the area. Figure ?? shows the map interface for this quest.

This quest has a time limit of eight minutes. When the time runs out the players are presented with the group's flood protection score, from zero to 100 percent, where 100 percent is a perfect score. The score is calculated by

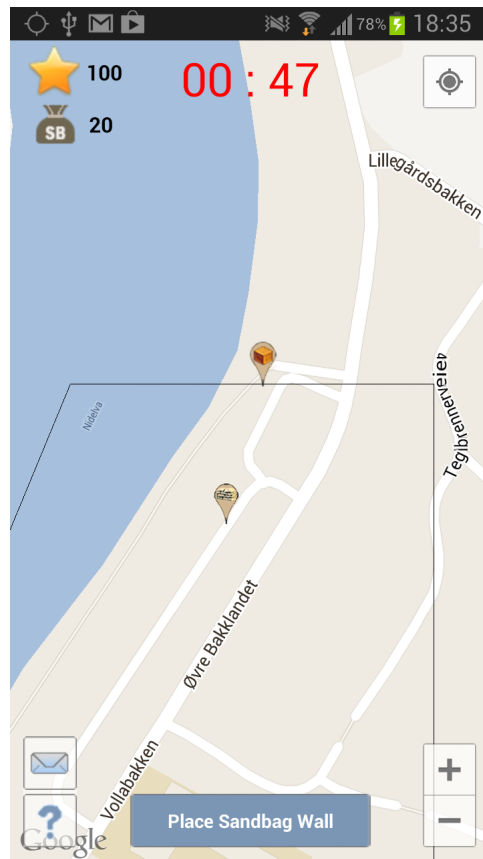


Figure 5.2: Flood Protection-quest

taking into account how much of the area the players were able to protect. When the players reach the after flood-phase, the severity of the flood is decided by the flood protection score.

For every sandbag wall the player places he is rewarded with points. At the end of the quest the players will also receive extra points, which is dependent on the group's flood protection score. To determine the score of each sandbag wall placement, two criteria are used, as listed below. The sum of all sandbag wall scores are used together with the total zone coverage to determine the flood protection score.

- Sandbag wall score
 1. Distance from river
 2. Proximity of other sandbag walls
- Flood protection score

1. Sum of sandbag wall scores
2. Zone coverage

Sandbag wall score Distance from the river is important, as the closer the sandbag walls are placed the more of the area they are able to protect. If the sandbag wall is placed within 5 metres of the river, it will have a distance score of 50. The score is then gradually reduced, and from 55 metres and farther away the score is 0. The algorithm for computing the distance between the river and the sandbag is described in Appendix B.2.

Sandbag walls also need to be placed near other sandbag walls to be effective. A single wall is not capable of protecting much by itself. For every sandbag wall that is within 10 metres of another, 5 points are added to the proximity score of both walls. The maximum proximity score is 25, which makes the maximum sandbag wall score 75.

Flood protection score The flood protection score is a percentage from 0 to 100 that illustrates how well the players did. To compute the score the sum of all the sandbag wall scores are divided by the optimal total score. The optimal total score is the maximum that the players can achieve. This is a situation where all sandbag walls are placed within 5 metres of the river, and within 10 metres of at least 5 other walls.

The river bank is divided into four zones, which are invisible to the players. To achieve a perfect score the players must spread their sandbag walls equally over the four zones. For each zone a zone score is computed. The zone score is a percentage between 0 to 100, where 100% means that the players have placed at least a quarter of the total sandbag walls inside it.

The average of all zone scores is computed and multiplied by the sum of the sandbag walls to give the flood protection score. If the players can place a total of 28 sandbag walls, each zone must contain 7 sandbag walls to achieve the optimal score. Pseudo-code of the algorithm is given below:

Listing 5.1: Flood Protection Score

```
computeFloodScore() {
  for each Sandbag {
    score = proximityScore + distanceScore;
    totalSandbagScore += score
  }
  optimalSandbagScore = maxProximityScore
                      + maxDistanceScore
```



```

maxPossibleScore = numberOfPlayers * sandbagPerPlayer
                  * optimalSandbagScore;

floodPercentage = totalSandbagScore/maxPossibleScore

optimalSandbagsPerZone = numOfSandbags/numberOfZones;

for each Zone {
    zoneScore = (numberOfSandbagsInZone
                /optimalSandbagsPerZone)
    totalZoneScore += zoneScore
}

averageZoneScore = totalZoneScore/numberOfZones
finalScore = floodPercentage * averageZoneScore * 100
}

```

5.3.3 Monitor Territory

Measuring the water level of the river is important to be able to predict if a river is about to overflow, as an early flood warning can save lives. In this quest, the players measure the depth of the water at different points along the river. If they encounter a critical rise in water level they must start an evacuation of the area.

Learning Goal

Players will learn that measuring the water level can be used for predicting floods. They will be sensitized to the fact that an early flood warning is important to be able to evacuate in time. The players must move along the river to measure the water, which promotes exploration of the territory.

Engagement Goal

Limited time to complete the quest and rewards for measuring water level are used to engage the players.

Collaboration Goal

To be able to measure the water level at all the points before the time runs out, the players must split up and decide who goes where. Coordination can be done through face-to-face communication, messaging or by observing where the other players are on the map.

Rules

The quest consists of five points along the river bank where the players must measure and submit the water level. The points are represented by a marker on the map. If the marker is blue the water has not been measured at that point, while if it is green the water has been measured there. A red marker denotes a situation where the player has measured a rise in water level that is critical. Figure 5.3 shows a couple of unmeasured points.



Figure 5.3: Measuring Points

The quest has a time limit of 7 minutes. If the players encounter a critical water level they are instructed to start an evacuation, which automatically triggers the evacuation quest for all players. If the players are able to start an evacuation before the time runs out, the remaining time is added to the evacuation quest.

The map displays the player's position and the position of measure point markers. The locations of other players are displayed, which can be useful for deciding where to go.

5.3.4 Evacuation

When a flood warning is given, the appropriate action is to evacuate the area and go somewhere with a higher elevation. In this quest the players must run to an evacuation zone before the time runs out.

Learning Goal

Players will learn that evacuation is the right course of action when a flood warning is issued. They will get sensitized to the geography of their local area as they have to move to a location with a higher elevation. This can make them aware of where it is smart to go if a real flood occurs.

Engagement Goal

Players will have a very limited amount of time to evacuate, and if they do not reach the destination in time, they will die. This could produce a feeling of adrenaline rush, and motivate them to do their best. By reaching the zone in time they are rewarded with points.

Collaboration Goal

This is a "single player" quest with no specific collaboration goal.

Rules

Players are told that a flash flood is coming and that they need to evacuate. The map contains an evacuation zone that the players must go to. The quest has a time limit of 3 and half minutes. In addition, the players will receive extra time if they were able to start an early evacuation in the Monitor territory-quest. If they players reach the zone before the time runs out they are rewarded with points, if not, they die. A death results in a one minute suspension from the game, as well as detracting 150 points from the player that dies. Figure 5.4 shows an evacuation zone.

5.3.5 Search and Rescue

The flood has hit the area and several people have been reported missing. The government has asked for volunteers to help in the search. The players must search the area and when they find a person they must notify the local government.



Figure 5.4: Evacuation Zone

Learning Goal

Players will get sensitized to the dangers of flooding and to the impact of flood protection. This is done by adding flooding to the map, making it possible for the players to die. They will also encounter people that are dead or injured, increasing the immersion. Because the players must physically search the area to find people, they could learn more about their local area.

Engagement Goal

For every person the player finds he will be rewarded with points. The player has a limited time, which could motivate the players to hurry to find as many as possible.

Collaboration Goal

To have a better chance of finding all the missing people the players should coordinate who goes where. Coordination can be done by face-to-face communication, using the messaging functionality or by observing the location of other players on the map.

Rules

The area has been hit by the flood as the river has overflowed. The players must look for missing people in five different search zones near the river. The missing people are non-player characters (NPCs) and they can be dead, injured or dehydrated. The search zones contains one NPC each. The NPC remains hidden until the players are within 25 metres of his location. When the player gets close enough he can interact with the NPC to discover his condition. After interacting with the NPC, the player must notify the authorities of the situation. By successfully doing so the players are rewarded.

The map displays the player's position, the search zones and, if in range, the missing persons. The position of other players are also displayed. The search zone has a transparent red color if it is unsearched and a transparent green color if it is searched. The flooding is displayed on the map as a transparent blue color as a widening of the actual river. Figure ?? shows how the map interface looks for the player, except that in this screenshot all the NPCs are showing.

If a player walks into a flooded area he dies. This results in a one minute suspension from the game and detracts 150 points from the player. The algorithm for detecting if a player is inside a flooded area is described in Appendix B.1.

5.4 User Interface

This section describes the user interface. Screenshots of the prototype are used as a visualization. Note that this is the user interface created for the third iteration of the application. The old user interface is briefly explained in the first iteration chapter.

5.4.1 Authentication

When the player first starts the prototype he must login using his Facebook account. After logging in he is met by a dialog where he is asked to give his permissions to the application for use of his Facebook data. After accepting he is taken the welcome screen, shown in Figure 5.6. After clicking the screen he is taken to the main menu, as displayed in Figure 5.7.

5.4.2 Main Menu

The main menu displays a list of menu options. The player starts the game by clicking "Play". He can see his game profile by clicking "My profile", a list

Quest	Learning	Engagement	Collaboration
Flood Protection	Sensitize players to the importance of flood protection. Push knowledge of the local area.	Players must collaborate to manage resources under time pressure. Rewards and leaderboard.	Coordinate sandbag placement effectively. Share sandbags. Message functionality.
Monitor Territory	Sensitize players to the importance of early flood warning. Push knowledge of the local area.	Coordination under time pressure. Rewards and leaderboard.	Coordinate who goes where. Message functionality.
Evacuation	Sensitize players to the fact that evacuation is the correct strategy when a flood warning is given. Push knowledge of the local area.	Time pressure. Rewards and leaderboard.	No specific goal.
11 Search and Rescue	Sensitize players to the dangers of flooding. Push knowledge of the local area.	Coordination under time pressure. Rewards and leaderboard.	Coordinate who goes where. Message functionality.

Table 5.1: Summary of Quest Goals

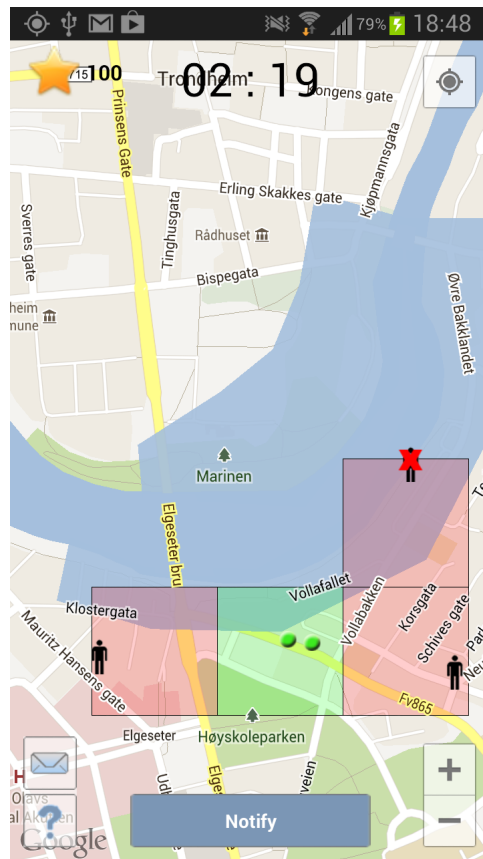


Figure 5.5: Search and Rescue-quest

of his friends by clicking "Friends", the leaderboard by clicking "Leaderboard" and his inbox by clicking "Inbox". He can also log out of the game by clicking "Log out".

5.4.3 The Game

By selecting the **Map** option in the menu, the player is taken to the game map, as shown in Figure 5.8. The map displays the player's current location as a blue dot surrounded by a circle. The circle represents the GPS accuracy of his location. The smaller the radius, the more accurate the location. Other players that are online are displayed as green dots. The point of showing other players' locations is to make it easier to collaborate. If you see a player is in an area, you know that he will most likely complete the quest objectives in that area, saving you the trouble of going there.

The map also displays quest objects and quest zones. Quest objects

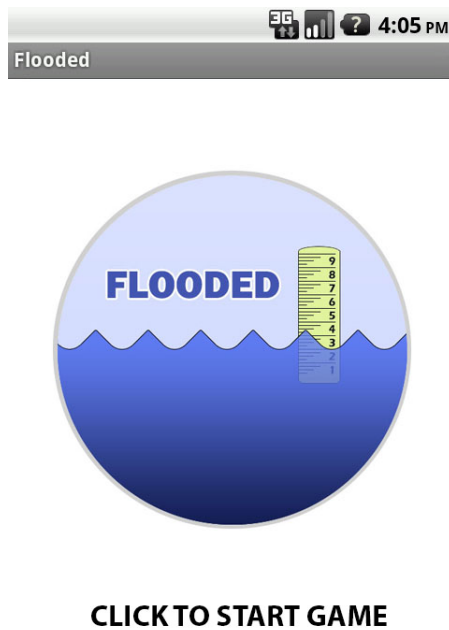


Figure 5.6: Welcome screen

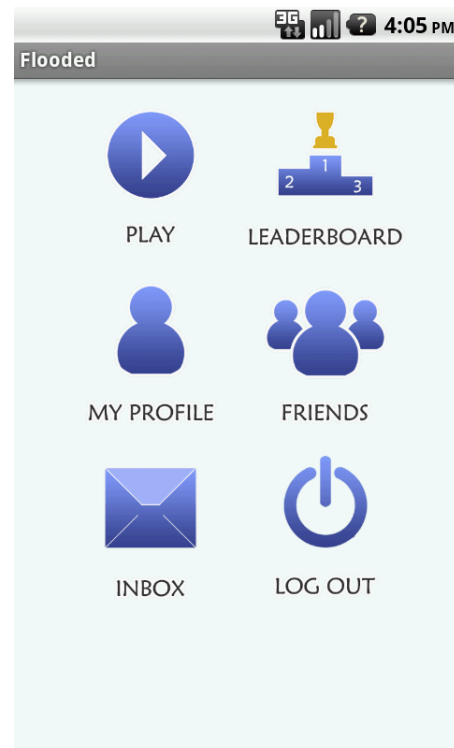


Figure 5.7: Main menu

are represented by map markers, while zones are represented by polygons. The map is global, which means that all the players see the same map with the same quest objects and zones. Completing quest objectives updates the map for all players, either by removing, changing or adding markers, or by changing the color of a zone.

An overview of the different user interface elements can be seen in Figure 5.10. The different elements will be explained more in detail in the following paragraphs. The screenshot is taken from a player currently in the Flood Protection quest, and as such only markers from that quest is showing. An overview of all markers can be found in Table 5.2.

Presenting Information

The user is presented with information in three different ways: The HUD (Heads-up display), which is always displayed on the screen, through small feedback messages that appear for a short duration and through message dialogs that the user must terminate themselves.

The HUD can be seen in Figure 5.10. The numbers at the top of the map

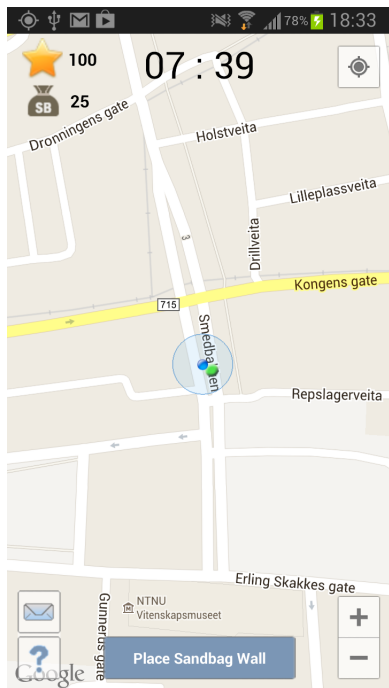


Figure 5.8: The Map

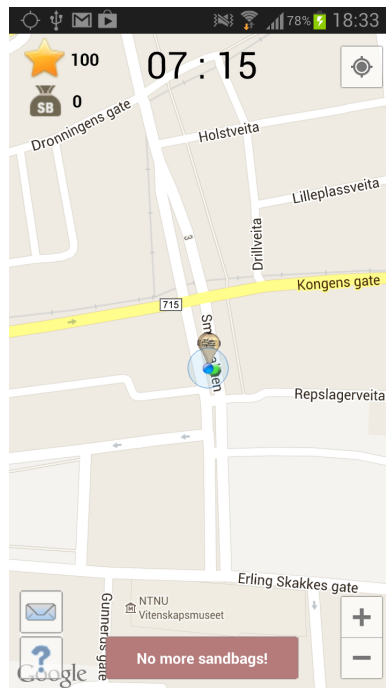


Figure 5.9: No more sandbags

is the quest timer, which shows how much time is left before the quest is finished. The timer turns red when there is a minute or less left, its default color is black. The number beside the star shows how many points a player has, while the number beside the sandbag shows the number of sandbags. The number of sandbags are only displayed during the Tutorial and the Flood Protection quest.

An example of a feedback message is shown in Figure 5.13. These are displayed when the user interacts with the game, such as placing a sandbag wall or picking up a crate.

An example of a message dialog is shown in 5.11. Dialogs are used for pushing quest information, such as the goal of the quest. They are also used for confirmation and quest interaction, such as confirming a sandbag wall placement.

User Controls

The button in the top right corner is used to center the map on the player's location, while the '+' and '-' signs are used to zoom in and out respectively. Players can also pan and zoom on the map by using finger gestures. The Message-button is used to open up a Messaging-dialog where the players can

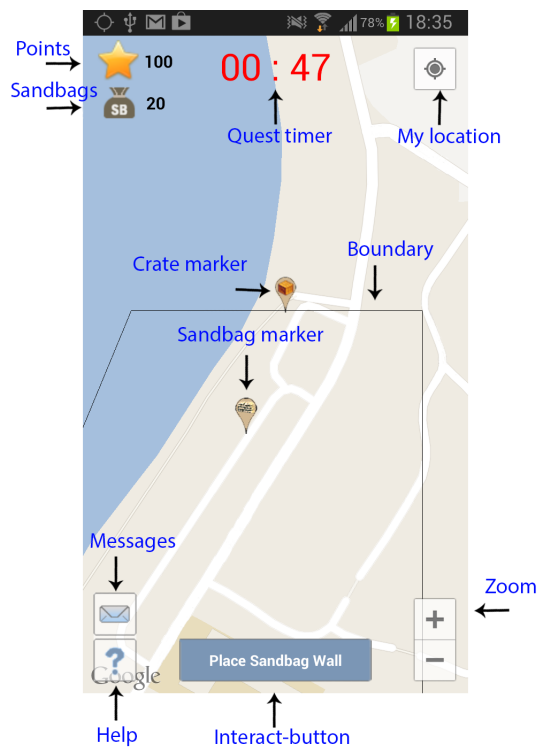


Figure 5.10: User Interface

send or browse messages. This is explained in more detail in Section 5.4.6. The question mark is a help-button, which is used to redisplay the initial quest information-dialog. This is useful if the players accidentally terminates the dialog before they read it, or if they forget what it contained.

The player can perform quest actions in two different ways. Either by clicking the interact-button, or by clicking on map markers. The two interaction methods corresponds to different quest actions. That is, using the interact-button will not perform the same action as clicking on a map marker. A summary of all quest actions can be found in Table 5.3. The evacuation quest has no explicit quest actions, as the only goal of the player is to physically move to the evacuation zone.

Flood Protection

Players can place sandbag walls wherever they want. This is achieved by using the interact-button, as shown in Figure 5.8. By clicking "Place sandbag wall", a confirm dialog pops up. If they click yes, a sandbag marker is placed at his location, and five sandbags is withdrawn from the player's inventory. The sandbag wall will automatically display on the other players' maps as










Quest	Description	Image
All	The player	
All	Another player	
Flood protection	Sandbag	
Flood protection	Crate	
Monitor territory	Unmeasured water level	
Monitor territory	Measured water level	
Monitor territory	Critical water level	
Search and Rescue	Alive NPC	
Search and Rescue	Dead NPC	

Table 5.2: Map markers

Quest	Interaction	Action
Flood protection	Interact-button	Place sandbag wall
Flood protection	Marker click	Pick up crate
Monitor territory	Interact-button	Start evacuation
Monitor territory	Marker click	Measure water
Search and Rescue	Interact-button	Interact with NPC
Search and Rescue	Marker click	Notify

Table 5.3: Quest Actions

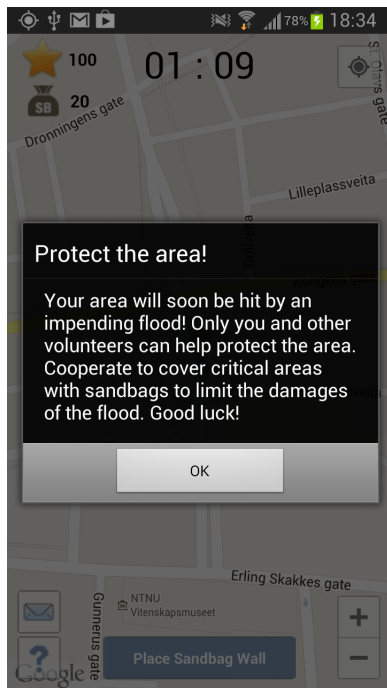


Figure 5.11: Message Dialog



Figure 5.12: User Interface

well. Picking up a crate is accomplished by clicking directly on the crate marker. The crate is picked up if the player is within 10 metres of the crate. This will remove it from the map for all players. Clicking on a sandbag wall marker will simply display "Sandbag wall" above the marker. When the player is out of sandbags the interact-button will turn red and the text will change to "No more sandbags". This can be seen in Figure 5.9.

Monitor Territory

The measure points are scattered throughout the map. Measuring the water is achieved by clicking on the measure point markers. The player needs to be in a certain range of the marker. Clicking the marker, while in range, will display a dialog. The dialog shows the normal water level, the current water level and the difference. The player needs to type the current water level and submit it by clicking "Submit". Submitting the water level will change the marker from a blue marker to a green marker for all the players, to indicate that the objective has been accomplished. If the water level difference is critical, the text color will be red. This indicates that the flood is approaching. The player must then start an early evacuation by clicking the interact-button, which is displayed in Figure 5.12. Measuring a critical

water level will also change the marker to a red marker, to make it easier for the players to see.

Evacuation

There is no direct user interaction in this quest. The player can see how much time is left in the quest timer, and the evacuation zone is displayed on the map. They simply have to use the map to navigate to the zone and reach it in time to be successful.

Search and Rescue

The search zones are displayed as polygons. They are red if they are unsearched and green if they are searched. A view of how the map looks is displayed in Figure 5.13. Note that the NPCs are hidden from the players unless they are within a certain range. They are displayed here for illustration purposes. The example shows two players, three NPCs, of which one is dead, and four search zones, of which one is searched. An alive NPC is displayed as a black stick figure marker, while a dead NPC is the same with an X over the marker.

The player has to physically traverse the search zones, and when he is within 50 metres of an NPC he appears on the map. The player then has to move within 15 metres of the NPC and click on him to interact. His state will appear in a dialog popup where the player is told to notify the authorities. The player has to click on the interact-button and choose the correct state to complete the quest objective. This will change the color of the search zone from red to green for all the players.

When the flood hits the players can see a visual representation of it on the map. This can be seen in the example as the transparent blue color that extends the river. The search zones may be partially flooded. When a player walks into the flood and dies, a message dialog is displayed that states why the player died and how long it is until he revives. The interact-button changes color to red, and the text changes to "You are dead!". A progress bar also appears on the screen, as seen in Figure 5.14. The progress bar is empty at the beginning and full when a minute has passed. When the progress bar gets full, the player is revived and the progress bar disappears. A short feedback message is also displayed. This can be seen in Figure 5.13. The interact-button changes back to its original color and text.

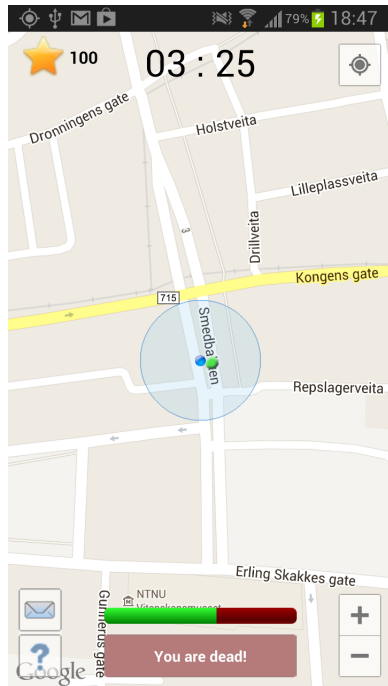


Figure 5.13: Player is dead



Figure 5.14: Player is revived

Leaderboard		
Position	Name	Points
1	jakethesnake	491
2	T	210
3	HenrikF	157
4	testdevice	0
5	prebenmann	-57

Figure 5.15: Leaderboard

My profile

testdevice

Rank: Civilian

Points: 0

Level progress: Sandbags: 25

Figure 5.16: Player profile

5.4.4 Player Profile

Selecting **My profile** takes the player to the screen shown in Figure 5.16. The profile screen displays the player's Facebook name and Facebook photo, his rank, as well as how many points and sandbags he has. The player's points are also displayed as a progress bar that represents the current level progression of the player. When the bar gets full the player gains a new level,

which means promotion to a higher rank. If the bar is emptied the player is demoted to a lower rank.

5.4.5 Leaderboard

Selecting **Leaderboard** displays the screen shown in Figure 5.15. It lists the players according to how many points they have.

5.4.6 Messaging Functionality

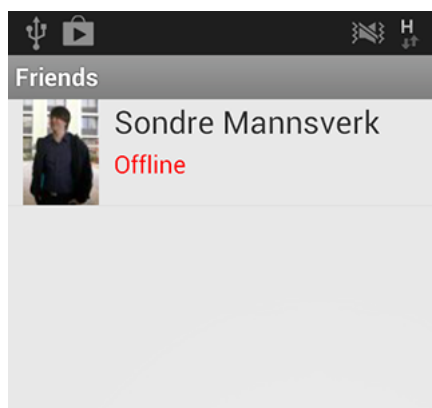


Figure 5.17: List of friends

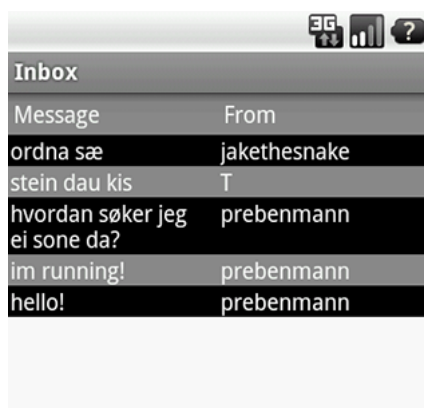


Figure 5.18: Inbox

Players can send messages to each other, either from the game or through the menu. The **Friends** menu displays a list of the player's in-game friends, as shown in Figure 5.17.

The friends list consists of all the player's Facebook friends that have the game installed. By clicking a friend's name he is presented with two choices, "Give gift" and "Send message". By clicking "Give gift", he takes five sandbag from his inventory and sends it to the chosen friend, while selecting "Send message", opens up a message dialog.

Players can browse their messages by selecting **Inbox** from the menu. The inbox lists all the messages of the player, as show in Figure 5.18. When someone sends a message the receiver will also get a notification that instantly displays the message on the screen and in the status bar.

The players have access to the messaging functionality through the **Map** screen as well. If they click the message icon on the HUD, they are taken to a dialog with three choices: "Message all", "Send message" and "Inbox". Clicking "Message all" opens a normal "Send message"-dialog. The difference is that the message will be broadcasted to all the players in the game. This is

useful for coordinating quest actions. Clicking "Friends" open up the **Friends** screen, while "Inbox" opens up the **Inbox** screen.

CHAPTER 6

TECHNICAL DESCRIPTION

The prototype is developed as a standalone Android application. To play the game the players need to login with their Facebook account and give permission to the application to fetch some of their Facebook information. Connection to Facebook is realized through the Facebook SDK 3.0 for Android, which supports basic methods to login, get user data and retrieve friends list and profile pictures, to name a few.

As the game is location-based, it requires a displayable map of the player's current location, as well as any relevant game-related locations, such as quest objects and other players. The map functionality is implemented using the Google Maps Android API v2, which offers easy access to most of Google Maps' features. By using the API, map markers, such as for the player's current position, can be added to the map. The API also provides zoom and panning functionality.

Quest and player data is stored in a MySQL database hosted on my server. PHP scripts are used for both fetching, updating and inserting data. When a PHP fetch script is called, data is returned as JSON objects. Gson, a Java library, is used for converting the JSON representation to Java Objects that can be understood by the application.

When a player does an action in the game, such as placing a sandbag wall or picking up a crate, a request is sent to the server to update the database. In addition to updating the database, the server notifies the other players' devices of the action. The other players' maps are subsequently updated. To support this functionality, Google Cloud Messaging (GCM) is used. GCM allows me to send data from the server to the players' devices.

A more comprehensive overview of the system is given in Appendix C.

6.1 Technological Choices

This section gives an overview of the technologies that were used to realize the game. A brief justification of my choices is given.

6.1.1 Android and JAVA

As I was making a mobile game I had to decide which devices I wanted to support. Devices run on different mobile operating system. As an example, HTC phones run on Android, while Apple phones run on iOS. Supporting more than one operating system would mean a significant increase in implementation time. I decided to create the prototype for only one operating system, as supporting several devices would not add any value to my thesis.

Recent surveys show that 92.3% of all smart phones run on Android or iOS operating systems.¹ The choice was therefore between Android or iOS, as it would make it easier to get people to evaluate my game. With Android having 75% of the market share, it was clear that creating the game for Android would be a good solution. Android applications are written in JAVA, while iOS applications are written in Objective-C. As I am more comfortable with JAVA programming, the decision to use Android would shorten the time to write the application. Especially since I had previous experience with programming for Android, and none for iOS.

6.1.2 Google Maps Android API v2

My game needed to have functionality for displaying a map, objects on the map and a player's position. As creating this functionality myself would be very time consuming I tried to find an application programming interface (API) that could provide this for me. I found the Google Maps API v2 for Android, and after some research I saw that it had all the features I was looking for.² It was free, it supported Android and it was well-documented. It also supported all the map-related functionality I needed in my game, such as customizable map markers, the ability to draw polygons and an interface for fetching the player's location from the GPS receiver and displaying it on the map.

¹<http://venturebeat.com/2013/05/16/windows-phone-jumps-to-third-in-global-smartphone-market-share-and-could-be-second-faster-than-you-think>

²<https://developers.google.com/maps/documentation/android/>

6.1.3 Facebook SDK 3.0 for Android

I wanted to support the use of the players' Facebook profiles in my game. An important reason was that I could use it as an authentication mechanism, which would shorten the implementation time. The main reason, though, was for the friends functionality. This can be used to build the friend's list for the players automatically, and in a long term perspective it could be used for inviting Facebook friends to play the game, submitting your score on Facebook and similar features. I quickly discovered that Facebook's software development kit (SDK) 3.0 for Android offered everything I needed to integrate my game with Facebook.³ An important feature it provides is Single Sign-on, which means that a player only needs to login to Facebook the first time he plays the game.

6.1.4 Google Cloud Messaging for Android

The players play on the same map, and I need to continuously update the map for the players to see each others' actions, both movement and quest actions. To facilitate continuous updates I looked at several options. The simplest was for the devices to manually query the server in regular intervals and update the map if any changes had happened. I quickly discarded this idea because it would be too much of a performance hit, it would also take its toll in terms of the devices' battery life and data usage.

A second option would be to implement the functionality myself, by sending messages from the server to the clients whenever a database update happened, telling the players' devices to query the server. This could, in theory, significantly reduce the number of updates, as they would only happen whenever another player did something, instead of at fixed intervals. This depends on the number of players and the frequency of their activity, though. Because the theoretical limit of simultaneous players is very high, this would have to be coupled with a mechanism that restrict updates from happening too often. For example, the server will only send out a message to update the database if it is more than 5 seconds since the last update.

The third option was to find a free service that could provide this functionality, which would help me save time on implementation and reduce errors. After some research I found the Google Cloud Messaging (GCM) service for Android. It allows the sending of data between the server and any Android device that is registered for GCM. I discovered that it had support for a very useful feature. It facilitated the sending of messages up to 4kb of data, which means that the devices could consume the messages directly instead

³<https://developers.facebook.com/android/>

of having to query the database for the data. As an example, a player places a sandbag, the location of the sandbag is sent to the database, the database forwards the sandbag information directly to all the other devices. I decided to go with GCM because it had all the functionality I needed, and the fact that it was free and had no quotas.

A more detailed account on how Google Maps, Facebook and GCM was integrated into my application is given in Appendix C.

6.1.5 Dealing With GPS Issues

When creating a game that relies on the GPS data of the players, several things needs to be taken into consideration:

1. The time it takes to get a location update
2. The (in)accuracy of the GPS location
3. A mobile device's limited battery capacity

As the GPS receiver requires a unobstructed line of sight to four or more GPS satellites, and has to receive a message from all of the satellites to determine a position, it takes some time to determine an accurate location.⁴ If the game relies on real-time or near real-time interaction between the player and the map, this can disrupt the gameplay experience and in some cases ruin the game entirely.

The accuracy of the received GPS location is not always perfect, often the real location is 10 metres away from the one that is displayed. The players can perceive this by a blue ring around them on the map, which represents the accuracy, or rather inaccuracy of the location. Sometimes it is obvious that the location is wrong though, such as if a player is suddenly placed in the river, while other times the difference can be too small for the players to notice. The second issue can actually be a bigger problem if the game relies on near-perfect accuracy, for example, within one meter of the location.

Managing the Issues

As explained, if the game is not designed with these issues in mind, it can be game breaking. In the case of the time it takes to receive GPS updates, my game relies as little as possible on real-time interaction. All the quest objects that the player can interact with are static. This means that they do not change their position and that the players are able to interact with them as

⁴<http://en.wikipedia.org/wiki/GPS>

long as they are in range. All the quests have a time limit, but having quest objectives that do not rely on instant updates of the GPS location mitigates most of the time-related issues.

For the second issue, in my game, the players do not have to be at the exact position of the game objective to interact with it. As long as the players are within 10-25 metres of the location, depending on the quest, they are allowed to interact with it. This mitigates the impact of GPS-inaccuracies, as the players are less likely to detect that their position is off, which ensures that the immersion into the game is not lost and reduces frustration. In the rare cases where the players' position is way off, the players will see this on the map and hopefully understand that they need to wait for the GPS to recalculate their position before they interact with the game.

It is also important to consider the cost of using the GPS, both in terms of battery and in terms of data usage. The GPS can drain the battery of a mobile device, which limits how long a play session can last. Using the GPS also costs money, and if a person does not have a data plan this can be a significant amount. I decided to keep the duration of my game to under half an hour to reduce the impact of this issue.

CHAPTER 7

FIRST ITERATION

In this chapter I describe the evaluation of the first iteration of the game. A brief status of the application is given. The results of the evaluation is presented, as well as how the evaluation was set up. Implications for the game design are explored.

7.1 Status of the application

The first iteration of the game was used to add content to the game. All the quests featured in the Game Design chapter were added, as well as other game dynamics such as the reward system. The major difference between the first iteration and the final version of the game was the user interface, which was the same as for the Autumn project. A screenshot of the old interface can be seen in Figure 7.1. The players' sandbags and points, and the quest timer was displayed in an information bar at the top of the map. All user interaction was done through a GUI menu accessed with the Android hardware menu button.

7.2 Evaluation Settings

The evaluation was performed with a groups of students, and involved a game session where they played the game, a short questionnaire and a focus group. The results were collected from feedback from the players, tracking of their movement during the game and other data from the database.

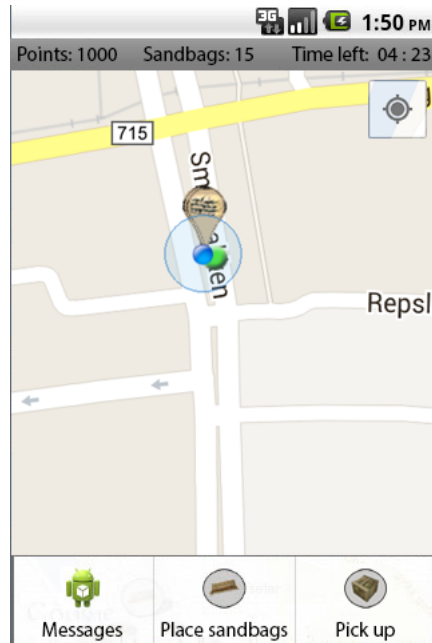


Figure 7.1: The old User Interface

The game session took place in the area around Samfundet and the discussion took place at NTNU, Gløshaugen. The evaluation was conducted with a group of five people, and lasted for two hours with around 30 minutes used for gameplay and the rest for walking to Gløshaugen, filling out the questionnaire and carrying out the focus group. In this section I will describe the preparation, execution and collection of data. I will also describe the players and the game area where they played.

7.2.1 General Preparations

As it is a location-based game, the game world is the real world. For my game, this means that the theoretical limit of how many players I can support is very high. It only depends on the capacity of the server(s) used, and how the game is set up. As an example, I could set up the game for the entire area of Sør-Trøndelag, which would require thousands of players to collaborate if they wanted to do well. Practically, it would be require significant work to prepare, while carrying out the evaluation would be even more work.

I decided to have three separate evaluations with three to five volunteers for each evaluation. I felt that this would give me sufficient number of data to analyze, and that between three and five people would be an appropriate amount for a focus group. Preferably, I would have tested and evaluated

the game with even more people, but due to time constraints only three evaluations were carried out.

7.2.2 Preparing the Game



Figure 7.2: A view of the river

The game was set up in the area around Samfundet, with the primary action area on the southern banks of Nidelven River. Setting up the game means that I had to place quest objects and objectives on the map, such as crates and measuring points. I had to set the location of the evacuation zone, the search zones, the game boundary and the flood zones. I also had to set variables for calculating the flood score, such as maximum number of possible sandbag wall placements. The duration of the quests had to be specified as well.

A picture of the river banks is displayed in Figure 7.2 (**NB: taken from the internet, no copyright**), while a map can be seen in Figure 7.3. The black polygon represents an approximation of the game area. The total time limit of the game was set to 26.5 minutes. The size of the game area was set with this time limit in mind. I will explain how the game was set up for each quest.

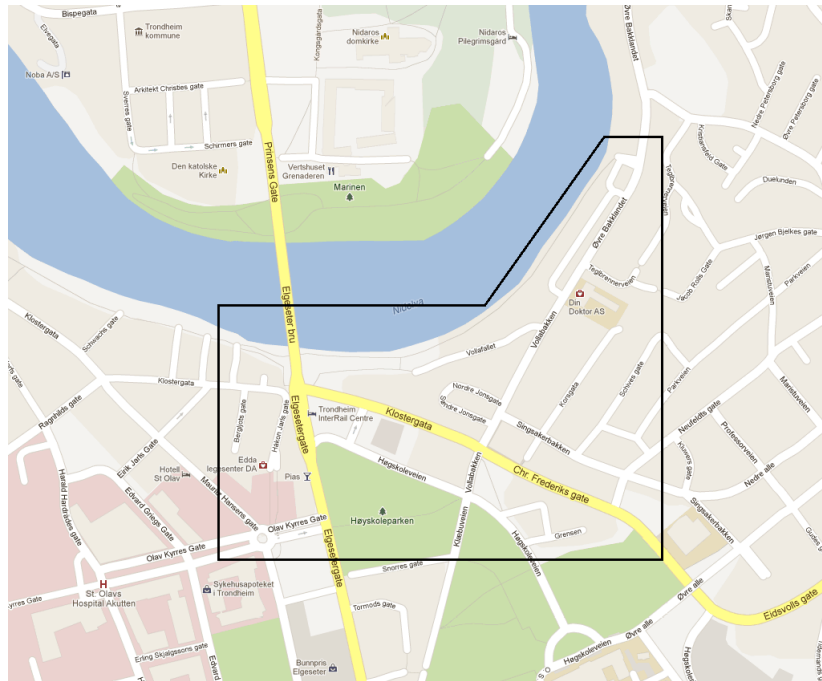


Figure 7.3: Map of the Game Area

Flood Protection

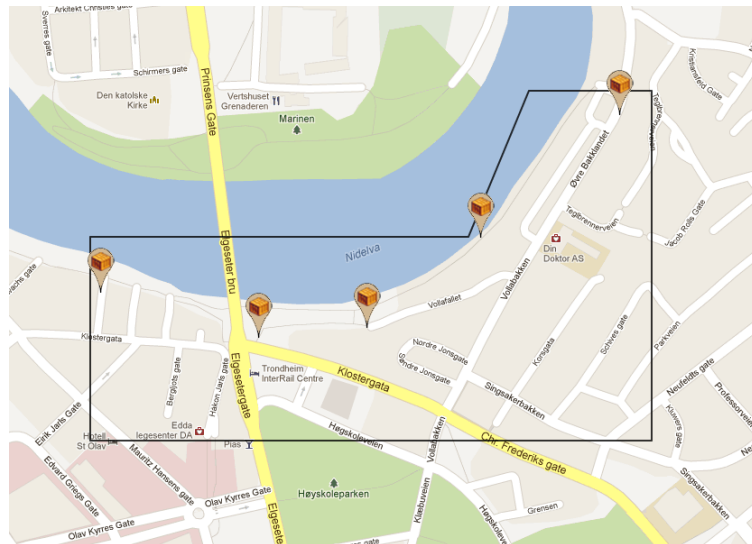


Figure 7.4: Quest Area With Crates

The boundary of the quest can be seen in Figure 7.4. Inside this boundary

is where the players can place sandbags. The four squares in the boundary represents the zones that are used for calculating the flood protection score, as explained in Section 5.3.2. These are not visible to the players. Five crates were spread across the area as shown in the figure. Two crates were removed before the second evaluation, and the number of sandbags needed for each zone was reduced to make it manageable for three players.

Monitor Territory



Figure 7.5: Measuring Points

Five measuring points were set up as shown in Figure 7.5. They were placed at a relatively small area, which would make it easy for five players to complete all the objectives. This was done because I wanted them to be able to start an early evacuation.

Evacuation

The evacuation zone was set up at the location shown in Figure 7.6. It was placed at a location with a relatively high altitude and at a running distance of about three to five minutes from the river. The distance was on purpose made a bit longer than what most people would be able to reach by walking,

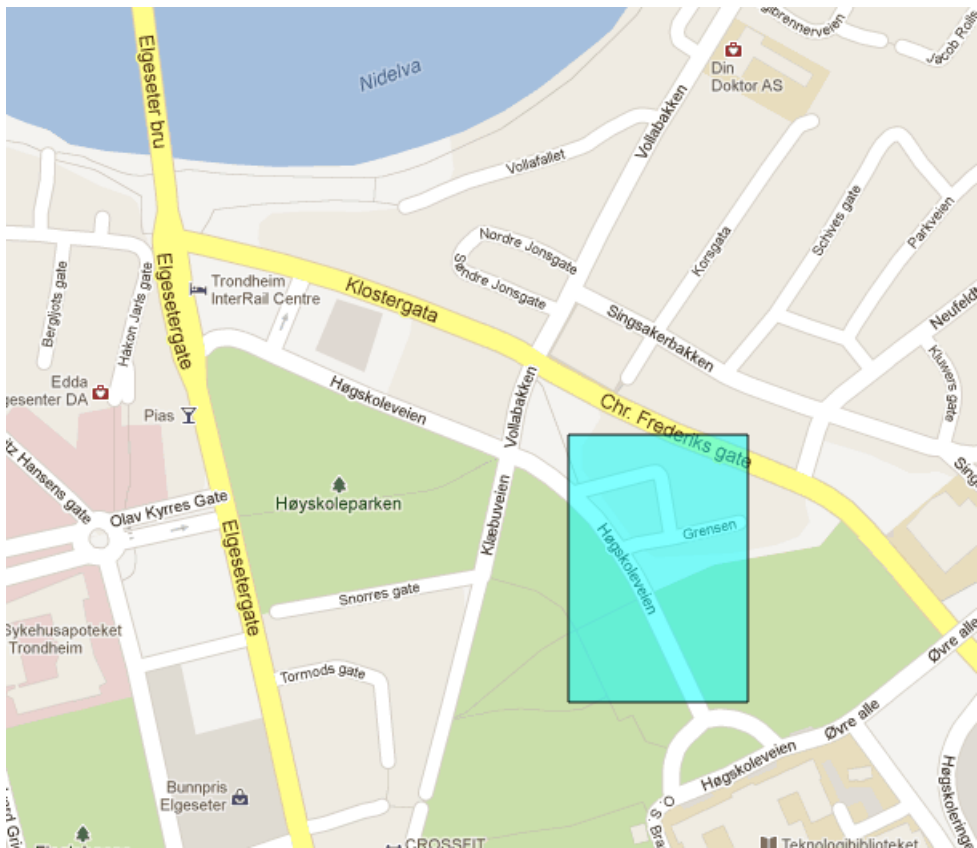


Figure 7.6: Evacuation Zone

to create a feeling of stress and to demonstrate the importance of haste in an evacuation scenario.

Search and Rescue

Five search zones were placed as shown in Figure 7.7, the red color represents the fact that they have not been searched. Figure 7.8 shows how the map would look like if the flood hits in full force. A few of the zones were placed where parts of them would most likely be hit by the flood. This was done to create a situation where a player would have the option of walking into the flooded area to search for an NPC, which in turn would lead to him dying and possibly increase his awareness of the dangers of flooding.

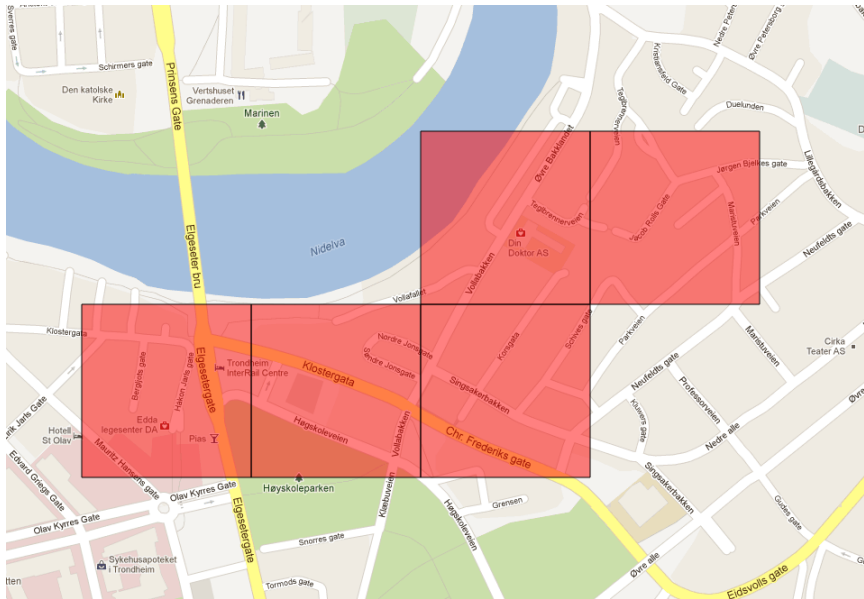


Figure 7.7: Search Zones

7.2.3 Testing

To prepare for the evaluation I had to make sure that it would run smoothly. This entailed preparing the devices I would use for the evaluation and performing a pre-evaluation to detect bugs.

Pre-Evaluation

A pre-evaluation was performed with two players playing the game. The main goals were to detect bugs and to find out if the time aspect of the game was about right, that is if the players would have enough time to complete the quests. The players were given instructions on how to use the game beforehand.

The results of the pre-evaluation suggested that I had to make some changes to the game area. It was apparent that five players would not be able to complete the quests in the given time, the main reason was that the first quest was on the other side of the river. By moving the quest to the same side as the others, I fixed the most pressing time concerns.

Although a usability test was not performed, the participants were able to give me a few tips regarding the quests. They felt that the flood protection quest was a bit unclear as you would place a single sandbag at a time. After a discussion, this was changed to placing a wall of sandbags instead, as this feels more like a protective measure against flooding. Their feedback also



Figure 7.8: A Maximum Impact Flood

helped me make few other minor changes to the quests.

Devices and Testing

IDI provided me with five HTC Desire HD Android devices I could use for the evaluation. The game was installed on all the devices and tested. One of the devices had issues with detecting the SIM card, while one had a very poor GPS receiver. That left me with 3 devices I could use. The game was also tested on my own device, which is a HTC Wildfire S, as well as on a Galaxy S1 and a Galaxy S3. This was done to ensure that the game would work as it should on multiple devices. On the Galaxy S3 testing was done quite superficially due to lack of time, but it was useful in terms of removing the most apparent device-dependent bugs.

7.2.4 Collection of Feedback and Data

I collected data from three different sources: the server, questionnaires and the focus group. As the players were playing their GPS data was sent to the server's database. This meant that I could visually recreate the path they took while playing the game. The players' points and overall performance on the quests were also saved in the database. This includes the coordinates of sandbags wall placements. After the game session the players answered a questionnaire with 20 questions regarding the game, followed by a focus group where I asked them more open-ended questions.

7.2.5 Players

The participants of the evaluation was five computer science students. Computer science students could be considered more patient in regards to bugs and crashes as they have first-hand knowledge of the difficulty of programming. They are also able to give more realistic feedback in terms of improving the application for the same reason. All five considered themselves hardcore gamers, which means that they are more invested than the average when it comes to getting good at games. Not having non-gamers a part of the evaluation could reflect the feedback regarding usability, because gamers could have less problems performing actions in the game than non-gamers. The fact that it is a location-based game, and none of them had tried such a game before, might mitigate that effect. The participants were all in their mid-twenties and with no physical handicap, which meant that they all had a good understanding of using mobile devices and had no major issue with the physicality of the game.

7.2.6 Execution

Players were given a brief description to the game before they started playing. They were told that they were playing a quest-driven game with four different quests in the context of flooding, and that the quests had a time limit that they could see in the top right corner of the screen. They were told that they had to go through a short introductory tutorial that aimed to teach them interface and the basics of the game, before being taken to the quests. The players logged in with their Facebook accounts and chose a username.



Figure 7.9: A player walking along Nidelven

7.3 Results

The first evaluation had five participants. Unfortunately one person was 20 minutes late, which delayed the evaluation. As the players wanted to use their own devices, I let them, even though the game was untested on some of the device types they used. This turned out to be a minor inconvenience as I will explain in this section. The players were able to complete the first quest without major issues, but an undiscovered bug related to time synchronization led to only one player being able to play the next 3 quests. The rest were stuck in the first quest with 1 hour left on the clock, making it impossible to finish the game session. The reason was that the game used a global synchronization that was dependent on the first player to start the quest. A design decision that in hindsight proved to be a bad one. The problem was triggered by the fact that the first player to start the quest, for some reason, had a device with a different set time zone than the others. In other words it was a bug that was highly unlikely to happen, but unfortunately it did during this evaluation. Although they were not able to play all the quests, I still managed to get some useful feedback on the first quest, and on the game on a more general level.

7.3.1 Flood Protection Quest

The group felt the quest was easy to understand, that is what their goal was (to place sandbag walls) and how to do it (click on the menu button).



Figure 7.10: Meanwhile, on the opposite side of the river

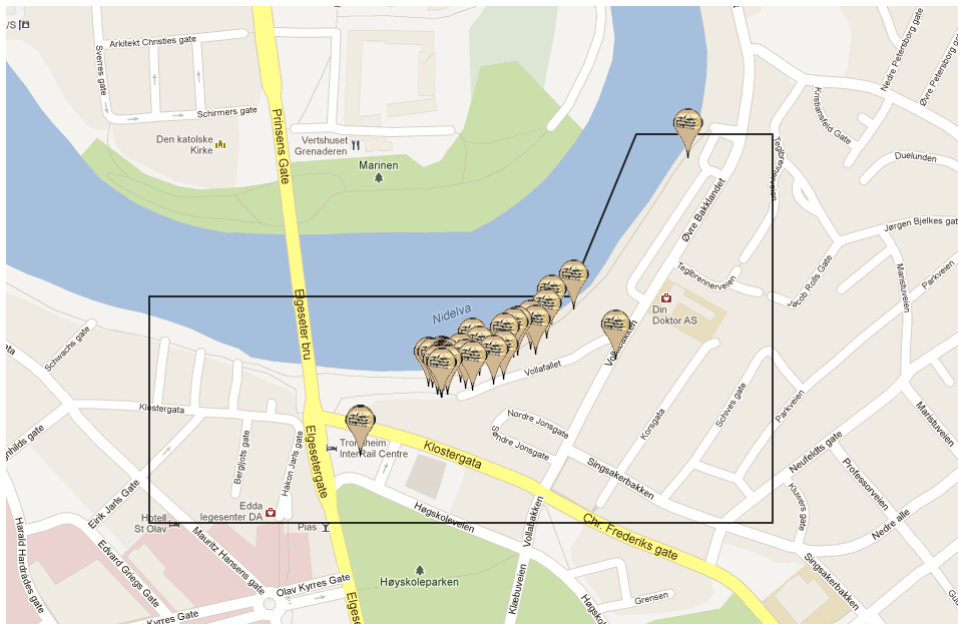


Figure 7.11: The players' sandbag placement during the first evaluation

The problem was figuring out how to be successful. Example of comments made were: *"Hard to understand how to get a good score"* and *"Hard to find out what sandbag placement was good"*. This is mostly intended, the players should discuss among themselves to find out what a good placement is.

While playing the game some of them discussed a bit where they thought

they should place them. They felt that placing them spread along the river would not be very effective in a real situation, because of the limited amount of sandbags they had. Three of the players decided to place them near a trail leading up to Samfundet. In the game however it is best to evenly place the sandbag walls along the river. The players felt that this was hard to understand in terms of the information they had received. The group's sandbag placements are shown in Figure 7.11. Their flood protection score was 23%.

They had several suggestions on how to make the quest a bit clearer, such as providing more feedback and hints. One suggested setting up "information plaques" at certain points with more hints on how to place sandbag walls, while one wanted a more thorough tutorial. Several players felt that you should get more feedback after placing a sandbag wall in terms of if it was a good placement or not.



Figure 7.12: "I wonder if I can use this to get more sandbags"

7.3.2 Technical

A synchronization error caused the players to get stuck in the first quest. When disregarding the synchronization error, three of the players encountered various errors or crashes while playing the game. Most of the errors could be attributed to the GPS, while a few were device dependent issues. The main issue with the GPS was that it would be slow to get the fix on a player after he had moved, causing the player's location to be displayed

incorrectly. The player would then have to wait for 5 to 10 seconds before his actual location was displayed. One player commented: *"The GPS put me in the middle of the river."*

Device Dependency

Two of the players experienced that the game crashed during their playthrough. Both were using Samsung Galaxy S3 devices. It is likely that these were device dependent crashes not discovered during testing, as no other devices crashed. One of the players also mentioned an error that appears to be device dependent, when turning his device sideways the initial message dialog reappeared. Interestingly, the players using the HTC Wildfire S and the HTC Desire HD, the only devices that the game were thoroughly tested on before the evaluation, did not encounter any crashes or errors. This shows just how difficult it is to create device independent Android applications, and underlines the importance of testing applications on a wide array of devices. The fact that the devices often run on different versions of the Android operating system makes it even more difficult.

7.3.3 Usability

The game presents quest information through message dialogs. A problem was that the players would often skim through the information and not get the content, or misclick the OK-button before they were able to read the message. One player suggested having a help button that would redisplay the message if they needed to read it again.

The players wanted to be able to pick up crates by clicking directly on the map marker, as they felt this would be more intuitive. Several players felt that in general the amount of popups they got were too many. When a player dies a pop-up appears with information on how long it is until he revives. They suggested displaying this information on the HUD (heads-up display) instead.

7.3.4 Collaboration

Three of the players collaborated during the game session. They used face-to-face communication as a tool for collaborating. The players commented that lack of time made using the messaging functionality impractical.

Leaderboard

Most of the players collaborated, but one player ran off on his own to pick up all the crates before the others could do it. He later commented: *"The leaderboard made me think I had to be the first to get to the crates, instead of collaborating."* The group agreed that the leaderboard was more suited for competition instead of collaboration. One suggestion made was to use group scores instead of player scores, that way the players could get an extra incentive to collaborate and in turn they could compete against other groups.

Face-To-Face Communication

During the first evaluation, face-to-face communication was used as a tool for coordination. Three of the players went to the most central area of the river, and discussed where they felt would be smartest to place their sandbag walls. Although the decision they made was ultimately wrong, it seemed that being at the same location made it much easier to collaborate. The limitations of the messaging functionality made this even more apparent.

7.3.5 Engagement

Feedback regarding the engagement of the game was collected through the questionnaire and the discussions during the focus group.

General Opinion

In the questionnaire, three of the players answered that they felt the game was engaging. Two players answered that they were neutral in terms of the game's engagement. Both of these players had significant technical issues during the game session, and one of them was using a Samsung Galaxy S3, which caused a few crashes. It is also important to note that the players only tried the first quest, and had to wait in frustration while I was trying to fix the problem. It is not possible to conclude that this was the reason they were neutral though. A player commented: *"It would be interesting to try all the quests!"*, which could indicate that he wanted to play the full game.

Motivating Factors

One player mentioned he liked the achievements he got: *"You are now a skilled volunteer"*, and that this motivated him to do well. Several players felt that the slowness of GPS updates had a negative influence on their enjoyment.

Replayability

One player felt that playing the quest one more time would be beneficial to get a better result. But in the long term he felt the quest would stop being fun after a couple of playthroughs.

7.3.6 Flood Awareness

Feedback regarding the game's flood awareness was collected through the questionnaire and the discussions during the focus group. Three of the players felt the game made them more aware of the dangers of flooding, the two others were neutral. Note that they only played the first quest, which could have an effect on the results.

A player commented: *"It made me think about what a good placement of a sandbag wall might be, which is something I've never done before."* The players had issues understanding where to place their sandbag walls, for different reasons. They felt it was not intuitive to spread the sandbags along the entire river, due to the limited amount of sandbags they had.

7.4 Implications for design

The main technical issue uncovered by evaluating the first iteration was that the global synchronization had a huge flaw. This had to be fixed before I could evaluate the game with more players. A device dependent issue where pop-up dialogs would reappear by changing the orientation of the device was discovered. Although the players were mostly happy with the user interface, they felt that the usability could be improved by making some minor changes. The most requested feature was to make it possible to pick up crates by clicking directly on the marker.

CHAPTER 8

SECOND ITERATION

In this chapter I describe the evaluation of the first iteration of the game. A brief status of the application is given. The results of the evaluation is presented, as well as how the evaluation was set up. Implications for the game design are explored.

8.1 Status of the application

Before the second evaluation, I removed the global synchronization as a hot fix to the problems I previously encountered. The bug where changing the orientation of the device would cause pop-ups to reappear was also fixed. I improved the usability by adding an alternative method of interacting with some of the quest objectives. This allowed players to interact with measuring points, crates and NPCs by simply clicking on them. A bug related to displaying the position of other players was discovered and fixed. The problem was that the game uploaded the wrong GPS data to the database.

8.2 Results

The second evaluation had three participants, all using different devices. The players were able to play through the entire game, but not without issues. One of the players forgot to turn off his wireless, and I forgot to tell him to do it, which caused his GPS updates to happen slower than they should for the first part of the evaluation. This meant that he had to wait up to 10 seconds to get a fix on his location. It also caused the game to act strangely, such

as spamming his device with constant dialog pop-ups at one point. After he turned off the wireless he had no such issues. A second player encountered a problem which I had not foreseen. The game uses the device's hardware menu button to open up the game's action menu. The problem is that his device, a Galaxy Nexus, did not have this button. Fortunately he was able to circumvent this issue and could play the game as intended, although he was two minutes behind the other players at all times. The third player had no issues.

8.2.1 Quest Results

In the first part of the focus group we went through each quest and discussed their performance and if they had learned anything. I will present the players' results, as well as the feedback from the players collected during the focus group.

Flood Protection

It seemed the players focused too much on picking up the crates that were placed on the map. The group's flood protection score was, interestingly enough, once again 23%. Only one of the players were able to place any sandbag walls, his placements are shown in Figure 8.1. The two others spent most of their time walking to the crate on the most northern part of the game area. The reason became apparent after discussing it during the focus group. The main issue was that they had problems reading the bar at the top of the screen, which displays the sandbags and the timer. Because of this they didn't realize that they started with 25 sandbags and that they only had eight minutes to complete the quest. As one player commented: *"I understood that I was supposed to collect crates and place sandbag walls. But I didn't see that I had sandbags to begin with, which could be because I can't see anything on my phone in sunlight. And I might have clicked through the message dialogs too quickly because of the time pressure."* He added: *"I wasn't aware of the time pressure at that time. I wasn't aware that we had that little time, so when we reached the crate, 6 minutes had already passed. It was a bit unclear that we had to be quick."*

The one player that did place sandbag walls didn't really know what to do with them. He commented: *"I didn't understand when I got the sandbags where it was naturally to place them."*



Figure 8.1: The players' sandbag placement during the second evaluation

Monitor Territory

The players were able to measure the water level at all the quest locations before the time ran out. One of the players started an early evacuation when there was 24 seconds left on the clock. It seems that all the players understood the goal of the quest and how to complete it. They also understood that they were able to start an early evacuation if they found a critical water level. As one player commented: *"We looked at the normal and the current water level and if there was a big difference it meant that a flood was about to arrive."*

Evacuation

None of the players were able to reach the evacuation zone in time, but it is important to note that they only had 24 extra seconds on top of the default three minutes and 30 seconds. The players all said that the lack of time was the reason they did not reach it. They were all able to find the zone on the map, and they understood that it was placed where it was due to its high elevation and distance from the river. When asked if they understood what they should do if a real flood warning occurred they answered: *"Get out (of the area)!"*

Search and Rescue

The easternmost search zone was removed before the evaluation, to make the quest more manageable for three people. Two of the players spawned inside the flooded area, while one was almost at the evacuation zone in an area without flooding. The players seemed to understand the purpose of the quest, that they were supposed to search the zones for missing people. A problem was that they were not aware that a flood had actually impacted the map. Two of the players thought at first that it was a Google Maps-related graphical bug, since the flood was the same color as the river. They suggested animating the flood when it arrived.

The two that spawned inside the flood barely got out of it before the time ran out. One of them was able to find an NPC inside a search zone, but he was unable to get to him due to the flood. The third player was inside a zone searching but he was not able to find anyone. Regarding the quest one player commented: *"I didn't really have the time to try it because I was stuck in the flood."*

8.2.2 Usability

Overall it seemed the players thought the interface was, for the most part, intuitive and easy to use, but that improvements could be made to increase usability, especially regarding how the game presents information. It is important to note that the main focus of the first iterations were on the dynamics of the quests rather than usability.

User Interaction

The players were able to use the interface to perform actions, such as sending messages and placing sandbag walls, as intended. A few players commented on the fact that the game used the hardware-button instead of a on screen-button to open up the menu. Google is currently phasing out the Android Menu Button. This caused issues for one of the players that had to change some settings in his device to be able to use the action-menu.

Displaying Information

As mentioned previously, the players had issues reading the information bar at the top of the screen due to sunlight. This caused them to not understand that they already had sandbags to begin with. It was also difficult for them to see when the timer was running out. One player comment|ed: *"It could have been displayed more clearly, maybe a "pling" sound and you could see*

the sandbags count upwards. And the timer, it didn't have any indication that there wasn't much time left. It should probably turn red, or do something that redirects our focus to that part of the screen." Another agreed: *"Yeah, I think you look at the map (and see just crates), and not the bar above (where the sandbags and timer is displayed). It's not that intuitive that you should look at the bar."*

8.2.3 Technical

One of the players encountered a crash during the game session. He was the one that did not turn off his wireless, which was the likely reason for the crashes he experienced, but this is impossible to know without further testing.

GPS

As for the first evaluation, a few of the players commented on the delay on GPS updates. One of the players had forgotten to turn off his wireless, which led to more inaccurate and slower updates than what is expected.

For this evaluation, the players' GPS data were uploaded to the database whenever their position had changed with at least 10 metres. A total of 409 locations were uploaded. Of these, 47 were deemed to be conclusively incorrect in relation to the player's actual location, which was decided by observation and using common sense. Note that locations that were approximately inside a 10 meter radius of the player's assumed actual location were not considered incorrect, as such a small inaccuracy would not affect the gameplay in any major way. This means that a 88,5% of the locations that were uploaded to the database for the second evaluation were deemed to be sufficiently accurate. Because not every GPS update is uploaded, this does not give the complete picture of the player's experiences, but it indicates that GPS inaccuracies can be a significant detrimental factor to the player's gameplay experience. Especially when you consider that the time it takes to get a fix on a player's location is not taken into account. Feedback from the players substantiates this claim: *"Unstable GPS position"* and *"GPS dropped out for a few minutes on last quest"* were some of the comments made.

8.2.4 Collaboration

Most of the players felt collaboration was necessary to do well in the game, but the messaging functionality was not used at all for collaboration, mainly due to the time it takes to write messages on a mobile device. During the

first evaluation one player ran off because he did not know that he was supposed to collaborate. The players in the second evaluation were told more explicitly that collaboration could be smart. This seemed to remove any possible confusion.

Messaging Functionality

The message functionality did not seem to have any practical use in terms of collaboration. The main reason is that it takes too long to type a message, time the players would rather use to complete quest objectives and move around the area. A remedy for this could be to have a messaging system where the players just click their screen and choose between a couple of pre-defined messages, such as "Lets meet here" or "I will go here". This would in turn create a marker on the map for the others to see. The issues with the current messaging functionality is illustrated by a comment made during the focus group: *"It takes too long to write and send the messages. Because I have to walk, there's traffic, I have to move when I can. I was starting to write a message: 'Where should we meet after we pick up crates', but when I was halfway through I stopped because it was too much work."*

Observation of Other Players

It was apparent that the players used each others' locations to decide where to go. Although this is not collaboration in the conventional sense, it is form of instinctive coordination that can happen if the players' are aware of each other's location. When asked how they decided where to go, one player commented: *"I looked at the position of the others, and went in the opposite direction."* Another added: *"Because we were so few people and had so little time it was pretty obvious what would be smart to do."*

8.2.5 Exploration

An important goal of the game was to facilitate exploration of the territory, and in turn try to increase the player's familiarity with the local area.

Tracking the Players

Logs of the players' GPS data were used to determine how much they had actually explored. The players' movement during the second evaluation is shown in Figure 9.2.

As can be seen, most of the activity is near the starting point of the game session, directly north of Samfundet. This is also where the players ended

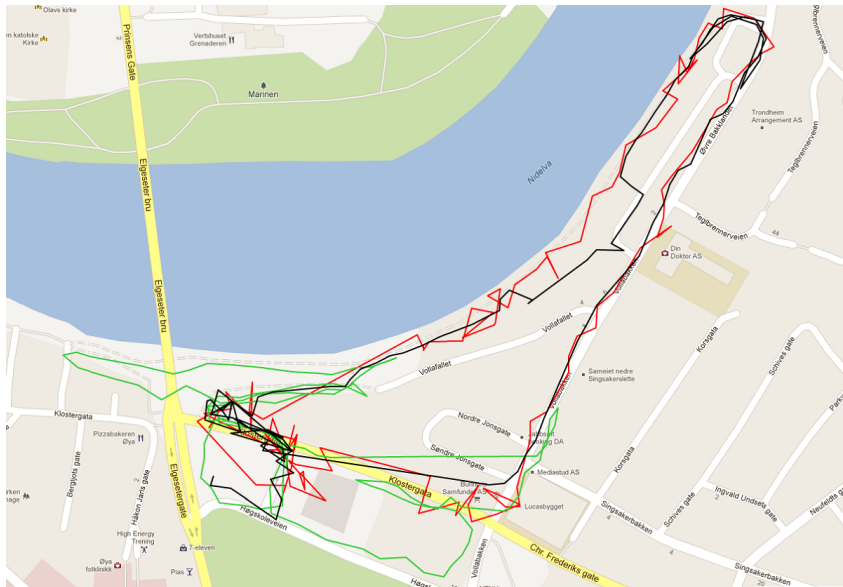


Figure 8.2: The players' movement during the second evaluation

up. There is also significant movement along the river, which is natural since most of the quest objectives for the first two quests are located there. Two of the players were stuck trying to get out of the flood, north of Samfundet, during the last two quests. The "green" player walked 2.012 kilometres, the "black" player walked 2.164 kilometres, while the "red" player walked 2.352 kilometres during the evaluation. The results seem to indicate that the game is useful in pushing exploration on the players.

Knowledge of the Territory

In the questionnaire most of the players agreed that the game had made them more familiar with the local area. One of the players experienced first hand the importance of knowing the territory. *"While I was trying to evacuate, Google maps lured me into a dead end. On the map it showed a path you could take to get to the main road. But there was a 5 meter tall wall blocking it."* When asked if he learned something from this he answered: *"Now I know where not to go if I have to evacuate from this area in real life."* The player walking into the dead end is shown inside the red circle in Figure 8.3.

8.2.6 Flood Awareness

Feedback regarding the game's flood awareness was collected through the questionnaire and the discussions during the focus group. I will present the



Figure 8.3: A player walking into a dead end

player's feedback, both generally for the game, but also specifically for each quest. Some of the information from Section 8.2.1 will be reiterated.

In general

In the questionnaire, two of the players answered that the game made them more aware of the dangers of flooding, the third player disagreed. The player that disagreed said that his problems reading the message dialogs were a contributing factor to his answer. He said that the focus group discussion made him reflect on the learning value of the game, though.

Regarding the use of the game as a tool for increasing awareness, one player said: *"I think it would be a good activity to have for example for a school in an area with a history of flooding. In the same way that classes learn about first aid, it (increasing flood awareness) could be useful."* The general feedback indicates that the game has the potential to be useful for increasing awareness.

When asked if they felt that playing the game once was enough in terms of increasing awareness of flooding, the players seemed to think so. One comment was: *"Because it doesn't last that long it is enough to play it once. It needs to last longer if there should be any gain of playing it more than*

once.” Another agreed: *“In terms of what the game offered I think so.”* Note that this is in regards to increasing awareness of flooding and not in increasing familiarity with the local area.

Flood Protection

As in the first evaluation, the players had issues understanding where to place their sandbag walls, for different reasons. They felt it was not intuitive to spread the sandbags along the entire river, due to the limited amount of sandbags they had. When asked if the quest made them more aware of how to manage a flood one of the players answered: *“I don’t know how realistic the game is, but placing a few sandbags in such a big area, does it make any difference?”*

Although the players struggled with the quest, it appeared to be a good source of reflection for some of the players. One player mentioned that he did not understand what a smart sandbag wall placement would be until after playing the Monitor Territory-quest.

Monitor Territory

The players had problems understanding the quest’s connection to a real life scenario. A reason could be that they did not read the quest’s message dialog properly. They seemed to miss the fact that they were measuring the water not to see if a flood were coming, but to see when the flood was coming, which was information that was presented at the beginning of the quest. This is illustrated by a player’s comment: *“I felt that the connection fell through. Because we placed a lot of sandbags and then we went to check to see if a flood was coming.”*

Evacuation

When asked if they understood that their performance in the Monitor Territory-quest (an early flood warning) gave them more time in the evacuation-quest, the player who disagreed that the game made him more aware of the dangers of flooding answered: *It’s logical when you reflect about it after you’ve played it. But when you’re playing it’s not that apparent.* He also stated that he felt the focus group discussion was necessary for him to understand the connection. This could indicate the need for having a debriefing-session after the game session to increase the learning potential of the game.

Search and Rescue

The players had problems seeing the flood on the map, I had to point it out to them before they understood where it was. Due to a lack of time, the players were not really able to do much searching, but it seems like the quest made an impact on at least one the players. Regarding the fact he was stuck in the flood, he commented: *"I don't know if it's bad thing that if you make bad preparations you will most likely die if there's a flood. It's a good lesson."*

8.2.7 Engagement

Feedback regarding the engagement of the game was collected through the questionnaire and the discussions during the focus group. The effects of external factors are presented, both specifically for GPS related issues as they are the main contributing factor, and generally for other factors.

General Opinion

In the questionnaire, two of the players answered that they agreed, and one player that he strongly agreed that the game was engaging. None of them felt they game were stressful in a demotivating way. It is also interesting to note that the all answered that they would like to play the game again, both in the same area and in a different area. The group's general opinion of the game in regards to engagement seemed to be higher than for the first group. They all actually said they thought it was fun, which was reflected in their comments. One player said: *"I think it was fun, it was like being at a treasure hunt."* Another added: *"It could be nice as a team building for a company, it would be a fun activity in that setting."*

External Factors - GPS Issues

The fact that it takes several seconds to get a proper fix on a player's location had an effect on their enjoyment. The players often had to stop moving for the GPS to update properly. The GPS would almost always get a sufficiently accurate location, the problem was the time it took. For some players this was a bigger problem than for others. This is probably due to the fact that they were using different devices, and that the performance of the GPS receiver varies from device to device. This can also be seen in the results of the questionnaire. Five of the players agreed that external factors had a negative effect on enjoyment, while two players strongly agreed. In the focus group after they all said that the GPS issues were a contributing factor. One of the players during the second evaluation strongly disagreed that external

factors influenced his enjoyment, that is probably because he did not suffer any issues during the playthrough.

External Factors - Other

In addition to the GPS issues there were several other external factors that affected the players. When asked about if there were any external factors that influenced their enjoyment, the players mentioned the traffic: One player commented: *"We had to wait for cars when we tried to get out of the flood zone, because the flood zone was along the road. We had to cross the road to get out of the flood and there was a long line of cars."* Another player added: *"There is a possibility that a few NPCs died because I didn't get a green man at the crosswalk."*

Two of the players complained that the sun made it hard to read what was on the screen. One of the players also had issues because he was connected to a wireless network for the first part of the game session, which caused GPS updates to be slow, and several strange errors. He felt that it was an annoyance, but stated that it did not have a major negative effect on his enjoyment.

In general, the participants expressed that playing the game was an engaging experience, despite all the bugs and issues they encountered. This could be because they had more patience with a location-based game as it was a new experience for them, and because they knew it was a prototype. The nice weather could also be a factor, although it did cause issues with reading the screen. I think it is likely that they would be less content with the issues if they were playing a released game at their desktop computer. This should be further investigated.

Motivating Factors

The players were also asked what motivated them to play the game. The level system, the fact that they game was location-based and the time aspect was mentioned. One player answered when asked what motivated him: *"How the game worked, that you were supposed to move and pick up things. It was a new experience. That you had to do something physical made it more engaging to pick up stuff etc. than if it was a regular game"* Another commented: *"It was exciting! I didn't know what the next objective would be."*

Several players mentioned that the leaderboard and point system made it more engaging: *"That we could collaborate and got points made it more fun."*

When asked about the leaderboard specifically the players seemed positive. They felt it was an added incentive to do well, as one player commented: *"It's an extra motivational factor that there is competition."* When asked if trying to avoid death was a motivating factor, one player answered: *"Yeah, it is not fun to get minus points."*

One of goals of the game is to try to put the players in stressful situations, both to mimic how stressful it is in a real flood but also to make the game more engaging. It is important, though, that the positive stress, which is a feeling of excitement that can motivate you, outweighs the negative stress, which is a feeling of not being able to handle the situation. A comment from one player could indicate that the game at least partly achieved this feeling of duality. It is impossible to say if the balance between the negative and the positive stress was perfect though. The player said: *"The time aspect was motivating, both negatively and positively. It was stressful after while, I didn't really grasp the gravity of the situation at the beginning. I just walked calmly to the crate. And when I was measuring water, suddenly the flood was coming and I had to get out of there and had just a few minutes to do so. This was both stressful and engaging."*

When asked if they thought location-based games could be fun, the general consensus seemed to be that the game had to be multi-player: *"It can be a fun activity if you are many playing together. I think this is important."* Another added: *"Yeah, being many is an advantage in this regard."*

8.3 Implications for design

The results of the second evaluation indicated that the current user interface was difficult to use when it was sunny. The glare on the screen made it very difficult to see the information bar, which caused players to not see that they had sandbags. The players also had issues seeing the timer, causing a few of the players to not fully understand the time constraints of the game. This had an impact on the players' performance in the game. Having user interaction happen mainly through the hardware menu button caused an issue for one of the players, as he had to change some settings to be able to use it on his phone.

CHAPTER 9

THIRD ITERATION

In this chapter I describe the evaluation of the third and final iteration of the game. A brief status of the application is given and the results of the evaluation is presented.

9.1 Status of the application

As the results of the two previous evaluations uncovered weaknesses in terms of the user interface that had direct impact on the players' performances in the game, I decided to create a new interface. The main goal was to mitigate the effects of the usability issues identified in the previous evaluations, while a secondary goal was to improve the looks of the game. The user interface is fully explored in Section 5.4. I will recap some of its features and give a brief justification on some of the changes I made from the old one. I created a few requirements for my new interface, which are listed below.

- **REQ1:** User interaction should be as easy as possible
- **REQ2:** User interaction should happen only through GUI buttons
- **REQ3:** The GUI buttons must follow the style of the Google Maps built-in buttons
- **REQ4:** The interface should not remove too much focus from the map
- **REQ5:** Information should be clearly presented
- **REQ6:** Players should be able to redisplay quest dialogs

The requirements were used as a basis for creating the interface. Four significant changes were made from the old interface, as listed below.

- Moved interaction from hardware menu buttons to GUI buttons
- Moved timer, sandbags and points from information bar to HUD
- Added progress bar when player dies
- Added help button to redisplay quest dialogs

As stated previously, the hardware menu button is being phased out by Android. This caused issues for one of the players. I decided to have an interface that only relied on GUI-buttons, both to support newer devices and to reduce interaction time and increase usability. Before the players had to press the hardware button, then the "Place sandbag"-button and finally confirm it. By removing the hardware button, placing a sandbag requires only two presses instead of three. Using the messaging functionality and interacting with quest objectives in the other quests also require one less press. These changes were grounded in **REQ1** and **REQ2**.

When creating the buttons I had to take into consideration that there are already three Google Maps buttons on the screen. One for centering the map on a player's location, and two for zooming functionality. **REQ3** was important to create a consistent style. To support this the message and help-button were created in the same size as the Google Maps-buttons, with the same background color. As I wanted the main interact-button to be clearly visible, I gave it a different background color and centered it horizontally between the other buttons.

To support **REQ6**, I added a help button to redisplay quest dialogs. Before, the players would often, intentionally or unintentionally, click the OK-button before reading the dialogs. With the new interface they are able to re-read the message if necessary.

To support **REQ5**, I had to change the way points, sandbags and the timer was presented. The timer is an important part of the interface, as it is essential that the players are aware of how much time they have left. To make sure that the players would notice it, I decided to place it at the top of the screen and gave it a big font size. The timer changes color to red when there is only a minute remaining. This is done to push the players to act when they are low on time. The points and sandbags were placed to the left of the timer with a smaller font size. Icons were used to draw attention, making sure that the players would be aware that they had sandbags to start with.

Several players mentioned that the number of dialog pop-ups were annoying. I removed one of the pop-ups and created a progress bar that is displayed when the player dies. The bar shows how long it is until the player revives, and appears just above the interact-button.

The positioning of the GUI-buttons and the information elements was done with **REQ4** in mind. I did not want the interface to dominate the screen, as it is important that the players can easily see their own position and the position of quest elements on the map. I decided to place most of the information elements at the top of the screen, with the interaction elements at the bottom. This frees up space in the center of the screen, which should be sufficient for using the map. The interface was previewed on a HTC Wildfire S, which has a very small screen size of 3.2 inches, and a Samsung Galaxy S3, which has a larger than average screen size of 4.8 inches. The interface looked good on both screens, and it was not a problem to use the buttons either.

9.2 Results

The third evaluation had four participants. They were able to play the game without any significant issues.

9.2.1 Quest Results

In the first part of the focus group we went through each quests and discussed their performance and if they had learned anything. I will present the players' results, as well as the feedback from the players collected during the focus group.

Flood Protection

The players were able to get a flood protection score of 28%. It is worth noting that the difficulty was adjusted for four players. Their sandbag wall placements can be seen in Figure 9.1. They placed 20 sandbag walls of a maximum possible 24.

A player commented on their approach: "We decided to place them on a line along the river bank." This is a coherent solution, the issue was that they did not sufficiently spread their placement, which left parts of the river bank uncovered. When I asked if they understood what they should have done differently to get a better result, one of the players correctly answered that they should have spread the sandbag walls more to cover more of the area.

When I stated that this was correct and explained how the flood protection score was calculated, another player said that he felt they should be told this information beforehand. He said that even if they played the game several times they might not understand that this was the correct approach, unless they were explicitly told so.

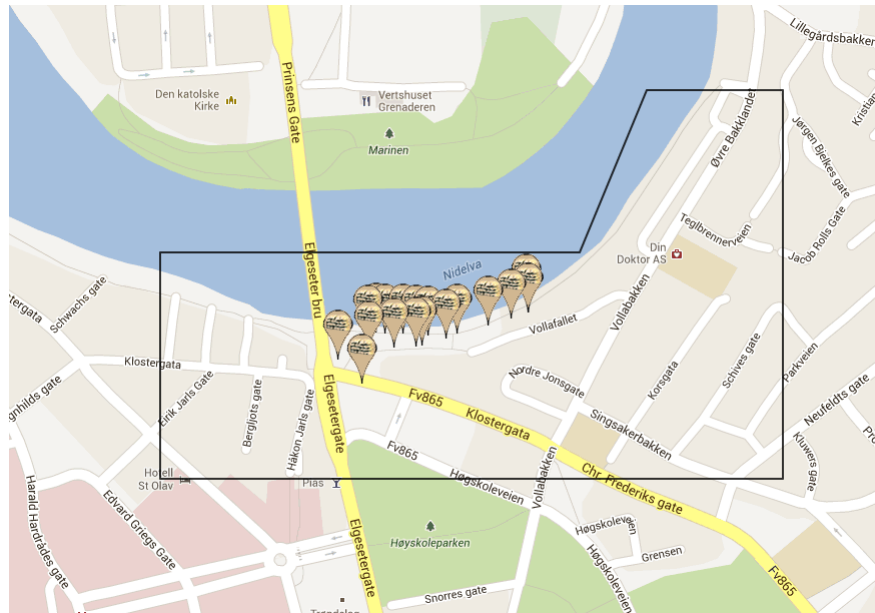


Figure 9.1: The players' sandbag placement during the final evaluation

Monitor Territory

The players measured the water level at all the points, but none were able to start an early evacuation in time. They understood what to do in the quest and how to do it. A player commented that he felt the quest was clear and intuitive.

Evacuation

Three of the players were about one to two minutes away from reaching the zone. The last player was able to reach the zone at the last second. Unfortunately for him, the GPS did not update in time for him to survive. He commented: *"I was there. I ran and I saw that I had one second left exactly when I reached the zone, but it didn't update in time. I was going to do a MacGyver and throw myself into the zone."* When discussing the fact that the GPS did not update instantaneously caused him to fail the quest,

he said: *"It was a bit my fault, I could have ran a bit more, but it was so hot."*

Search and Rescue

The players were able to find three of the four NPCs, but only successfully interacted with one of them. They mentioned that they saw two other NPCs on their map, but they were unable to reach them before the time ran out. The players felt they could have achieved a better result, as illustrated by one comment: *"I think we would have made it if we were in better shape and spread out. The steep hills from the river and towards the evacuation zones made it difficult."*

Two of the players walked together while searching, while the other two were searching separately. I asked them how they decided where to go. The two players that walked together said that they understood that it would be smarter to spread out, but it was clear that for them the social aspect of walking together and talking was more important than to find all the NPCs. The two others said that they wanted to search the zones furthest away from the others to be able to cover more zones.

One of the players died because he tried to walk into the flood to interact with an NPC that was already dead. He said that he thought he could have saved him. When I asked him if he did not understand that walking into the flood would be a bad idea, he answered: *"Well, when you say it like that... I did not really think too much about it when I did it, but in retrospect it was obviously not a smart decision. It (the fact that he died) made me stay out of the flood for the remainder of the quest."*

9.2.2 Technical

The players had no major technical issues during this evaluation. No crashes were reported and the players were able to play the game as intended.

GPS

For the final evaluation a total of 491 locations were uploaded, of these 56 were deemed to be off the mark. 88,6% of the locations were accurate. Note that there were significant differences in errors from device to device. The Wildfire S had only 2 errors, while the Galaxy S1 had 26. The Galaxy S2 and S3 had 14 errors each. Interestingly, there were no reports of GPS issues from the players, even though the tracking data shows that they had about the same number of GPS errors as the players of the second evaluation.

9.2.3 Usability

The players had no issues with the usability of the new user interface. Unlike the second evaluation, they were all able to see the timer and how many sandbags they had left. They felt the interface was intuitive. One player mentioned the usefulness of the help-button, as he several times misclicked the OK-button on dialogs before he could read the message.

The players were able to pick up crates, place sandbag walls and measure the water level without issues. There was one comment regarding the quest mechanics of the search and rescue-quest. One player commented: *"When I was starting to search, I thought, where are the markers on the map? I did not know that I had to be in range for them to appear. It was a bit confusing since it was a different mechanism than for the other quests. It should probably be explained in the tutorial."* Another suggestion was to add a tracking path to the map while they were searching, so that the players could see what parts of the zone they had already searched.

For the evacuation quest a minor improvement was suggested. The players were able to locate the zone, but suggested that the map should be zoomed out to show their location together with the zone to make it easier.

9.2.4 Collaboration

The players collaborated by using face-to-face communication and observing each other. The messaging functionality was attempted as a collaboration tool by one of the players without success.

Face-to-face Communication

Two of the players went together for the entire duration of the game session. They were communicating face-to-face when deciding where to go and where to place sandbag walls. The other two did not collaborate using communication at all, but one of them attempted at the beginning of the flood protection quest: *"I wanted to place them (the sandbag walls) as close together as possible. I tried to discuss this with another player, but he walked away before I was able to."*

Messaging Functionality

One player tried to get help from the others by sending a message, *"How do I search a zone?"*, but there were no response from the others. The players said that the lack of time was the reason that they did not use messaging for collaboration. A player commented: *"I did not use it, but I probably should"*

have. The lack of time made it difficult. But I feel the fact that we could communicate is a part of the potential of the game. It is very cool that you can communicate, it makes the game more realistic."

As an example of how it could be useful, a player said to the others: *"I probably should have used it during the Monitor Territory-quest, since you were far way from me and I did not know which you would take."*

I asked if having the option of pinging the map with default messages, such as "I'll go here", would be useful. Pinging would create a marker on the map where the players touched the screen and be linked with the message. The players agreed that this would make it easier to communicate.

Observation of Other Players

Most of the collaboration in the game was "indirect" coordination, in the sense that the players used the position of other players on the map when deciding where to go. One player said: *"We collaborated indirectly. I went in a different direction than the others and completed quest objectives there."*

Group Competition

A few of the players felt that having group versus group competition would increase collaboration. One player commented: *"It has a greater potential because it promotes collaboration. A 'We need to beat them'-mentality pushes collaboration on the players instead of individual thinking."*

9.2.5 Exploration

An important goal of the game was to facilitate exploration of the territory, and in turn try to increase the player's familiarity with the local area.

Tracking the Players

Logs of the players' GPS data were used to determine how much they had actually explored. The players' movement during the final evaluation is shown in Figure 9.2.

After completing the tutorial, all the players understood that they should move towards the river to place sandbag walls. The green player moved towards the western end, while the other three moved towards the north east. After the flood protection quest the players moved along the river to measure the water level. You can then see the players moving towards the evacuation zone, with the green player almost reaching it in time. In the search and rescue-quest the blue and black player went searching for missing

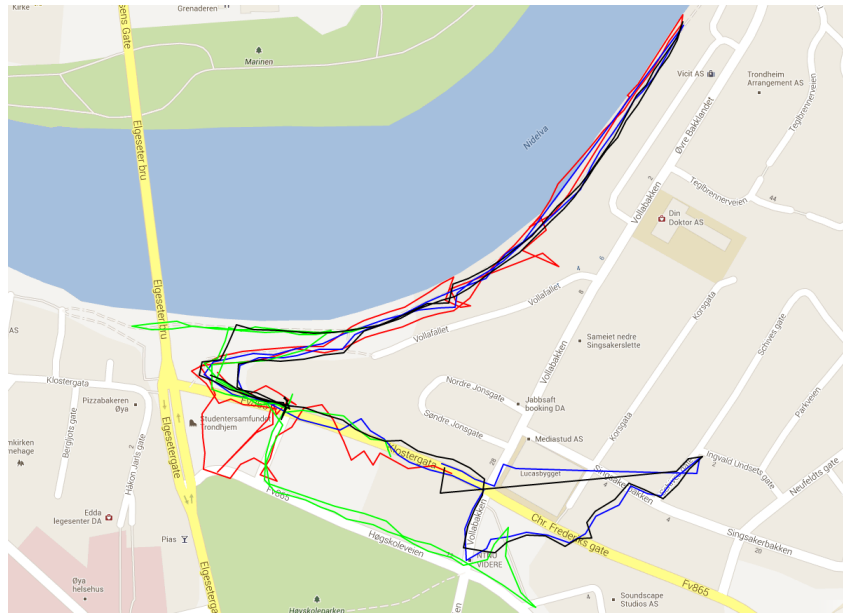


Figure 9.2: The players' movement during the final evaluation

NPCs to the east, while the green and red player traversed the search zones to the east.

The "green" player walked 2.022 kilometres, the "black" player 2.123 kilometres, the blue player 2.155 kilometres, and the "red" player 1.924 kilometres during the evaluation. The results are similar to those of the second evaluation, and indicate that the game is useful in pushing exploration on the players. The main difference was the path the players took at the beginning of the flood protection quest, and the fact that three of four players were not stuck in the flood and was able to search for NPCs more effectively than the previous group.

Knowledge of the Territory

Two of the players answered in the questionnaire that the game had made them more familiar with the area they played in. The two others were neutral. They said that they were already very familiar with the area, as one of them had lived in a house close to the river bank for two years, while the other had worked as a postman in the area. The players felt that the game had learning potential if it was in an area they had no familiarity with. One comment was: *"I think it is very useful if you want to get to know a new area. You are forced to move around and go to places that you otherwise would not."* In regards to flooding, a few players mentioned that it was useful

for learning where to evacuate: *"It can educate people on where it is smart to go when a flood arrives, to push them to go to an elevated area."*

9.2.6 Flood Awareness

In general

A few of the players mentioned that they did not feel the game increased their awareness of the dangers of flooding, because they already knew of the dangers. Although it did not have a big effect in regards to their own sensitization, they felt the game would be useful in this regards for others (that had less awareness). They felt that the game was more suited for increasing awareness than for teaching procedures in the context of flooding. To use it for teaching procedures, more information would have to be highlighted explicitly through a briefing and a debriefing. As the goal of my game is to sensitize users and not to teach specific procedures, such as how and where to place sandbags, these comments were to be expected.

One player felt that the game was slightly too unrealistic, in regards to the fact that material damages are not part of the game, and that this weakens the flood awareness aspect.

One of the players, who is a teacher, said that having a briefing before playing the game would be very beneficial in a learning scenario. The other players agreed that getting more information before playing the game would increase their learning.

When asked if they felt a debriefing was useful in terms of learning, they all agreed It would also make it easier for them to do well if they played the game a second time. One player said that it would make them collaborate better the next time, and achieved a better result. Another commented that, in a learning situation it is a must to have some kind of reflection and discussion after playing: *"We can discuss why we did things and why different things happened in the game. This helps us to learn more and to retain what we learned."*

When asked if they felt that the fact that my game was location-based made it more educative, a player responded: *"Yes, absolutely, even though it is not 100% realistic. You get to feel how it is to run, and you have to actually evacuate from the flood. You are down by the river and you are thinking, 'Maybe there could be an actual flood here'."* On the reason why a location-based game was more educative (than a regular game), one comment was: *"It has the potential to engage and increases the game's connection with real life, which I think increases its usefulness in a teaching scenario. Because the closer you are able to connect a game to the player's real world, the more*

realistic it is, which can increase the player's potential for learning." One player felt that the link to the real world made it easier for him to learn, because he was actually doing something instead of reading a book.

Flood Protection

One player commented on the issues of understanding where to place the sandbag walls. *"It was a fairly large river bank. It is unrealistic that we would be able to protect the entire area with the limited amount of sandbags that we had."* One player felt the game taught him something about managing a flood. He said: *"I had never thought about using sandbags to protect against a flood before playing the game."*

Monitor Territory

Regarding the early evacuation one player said: *"I think it's cool that if you read the quest properly and move fast, you can gain more time for the evacuation. It helps increase the excitement of the measuring quest, and makes it more realistic that you are able to evacuate, which makes sense."*

Evacuation

The players understood that the zone was placed where it was because of its elevation. One player suggested to make the zone wider, because there were many areas of a similar elevation that were not deemed safe by the game. He felt that this would increase the realism of the quest.

Search and Rescue

The players confirmed that they understood that a flood had impacted the area by looking at the map. A player commented that he felt that the flood should be animated, to show the flood hitting the area and then receding. The fact that he died in an area close to the evacuation zone, which is at a significant distance away from where the flood was on the map, made the connection a bit unintuitive.

When asked if they understood the connection between the flood protection-quest and the search and rescue-quest, one player commented: *"I think the level of flooding was based on the flood protection score. If we had been able to protect the area better, we could potentially save even more people."* When I told him that this was the correct interpretation he added: *"I did not get it while we were playing, but when I reflected about it now I understood. I think the way the quests are connected is good, but when I saw the flood was coming,*

I thought: 'But what was the point of the sandbags then? The flood is coming either way.' I did not really get the true consequences when I was playing. I think if the connection is explained clearly in the tutorial or through the message dialogs, it would make it easier to understand."

9.2.7 Engagement

Feedback regarding the engagement of the game was collected through the questionnaire and the discussions during the focus group. The effects of external factors are presented, as well as the motivating factors.

General Opinion

In the questionnaire, all the players agreed that the game was engaging, with one player strongly agreeing. Three players answered that they would play the game again in the same area and in a different area, while one would only play it again in a different area. None of the players felt the game was stressful in a demotivating way, and all of them felt it was stressful in a motivating way.

Three of four players felt the Search and Rescue-quest was the most engaging, while the fourth answered the Evacuation-quest. He was the one that reached the zone a second too late. From the focus group it was apparent that they enjoyed playing the game, and several of them even said it was fun.

External factors

Unlike the first two evaluations, GPS issues were not mentioned as a detrimental factor on engagement by the players. The traffic was reported as an issue by several players. One comment was: *"The road led us out of the zone. When the zones are this large the roads cause issues when you are trying to search the zones."* The players suggested decreasing the size of the zones a bit to reduce the impact of traffic on the search and rescue-quest. Another reason was to make the task more manageable. As one player commented: *"The zones were too big. I thought: 'Am I supposed to go through this entire area and search?' I had to cross traffic as well, which was a bit demotivating."*

Motivating Factors

The players were motivated by different elements of the game. One player mentioned the time aspect: *"For my part, the fact that I had limited time was enough to engage me. The fact that you had a timer worked really well, and motivated me instantly to do my best."*

One player was motivated by the leaderboard: *"It was motivating to get points for doing tasks. I knew I had a better score than the others and this motivated me even more."* Another disagreed: *"I did not really think about it all, I just wanted to complete the tasks."*

When asked how the fact that they game world was the real world (that the game was location-based) affected them, one player answered: *"It made it really fun. Very cool concept that you can go outside and play. You can run and be on the mobile at the same time, and the fact that it is connected with real life increases the engagement."* The players all agreed that location-based games could be fun, and that my game was a proof of that.

When asked if they were motivated to do their best, the views were somewhat split. On the one hand everyone felt the game was engaging, but the fact that they had to run was a demotivating factor for two of the players. *"I don't have the stamina to run."*, one of the players answered. The other added: *"If I knew I was going to run and did not wear jeans and bring a backpack, I would have made a better effort."*

The players did not feel the collaboration aspect had any effect on motivation, they had a few suggestions to improve this. One player would rather have played two versus two, where they would compete to get the best results. He said: *"If you were competing against the others, as well as collaborating it would make it even more fun. When you were done you could see who did best."*

CHAPTER 10

DISCUSSION

In this chapter I discuss the results of the evaluation of my game. I start of by looking at usability and technical issues, before I discuss the research questions. I discuss each sub-research question separately, before moving on to the main research question. Key information, such as quotes from the players from the evaluation, will be reiterated.

10.1 Usability and Technical Issues

Although usability was not part of the research questions, it is discussed, as I feel that good usability is important for both understanding the quests and for creating a frustration-free gaming experience. In other terms, the level of usability can have a direct effect on both learning and engagement. Technical issues also had an effect on the gameplay experience, especially during the first evaluation. The fact that the game is location-based will be the starting point of the discussion.

10.1.1 Technical Issues

The major issue encountered during the first evaluation was game breaking, and shows the importance of thorough testing. Although the issue that the players experienced was very unlikely to happen, as it was caused by one of the phones having a different time zone, testing it with more people and in a more structured way could have possibly discovered the bug at an earlier stage.

The other issues encountered during the first two evaluations illustrates the challenges of developing for Android, especially for a location-based collaborative game. Device dependency and GPS were particularly difficult to deal with. It is worth noting that the players in the last evaluation did not report any issues or crashes.

GPS Issues - Update Time

As I stated in Section 6.1.5, I designed the game to rely as little as possible on true real-time interaction. The fact that the GPS does not update your position instantly caused an issue for one of the players, though. The evacuation quest requires the players to reach the zone before the time runs out, which causes a problem if a player reaches the evacuation zone in one of the last remaining seconds, and the GPS is not able to update the location in time. This is exactly what happened to one player: *"I was there. I ran and I saw that I had one second left exactly when I reached the zone, but it didn't update in time. I was going to do a MacGyver and throw myself into the zone."* This illustrates that even if you consider these issues when designing the game, even the smallest real-time dependency can cause the game to not work as intended.

In general, the slowness of GPS updates were more annoying than game breaking, but coupled with inaccuracy it caused unexpected situations. The time it took to get an accurate location was not measured, but from the feedback from the players it was apparent that it was a detrimental factor to their engagement. The GPS would always get their accurate location, but in some cases the initial location would be way off, and the player would have to wait five to ten seconds before getting his real location. This issue is illustrated by the comment from one player: *"The GPS put me in the middle of the river."*

GPS Issues - Accuracy

The approximated GPS accuracy was found to be 88.5% and 88.6% for the last two evaluations, respectively. Interestingly enough, none of the players during the last evaluation reported any issues with the GPS, even though the data clearly shows that they had about the same accuracy as the players in the second evaluation. The reason for this was not clear from the feedback, but it could be related to the expectations of the players. If a player expects the GPS to update instantly with perfect accuracy, he is more likely to be frustrated if his expectations are not met. Another reason could be that if a player experience other issues, his patience will be low, causing him to

be more frustrated by GPS issues. An example of this is the players of the first evaluation that could only play the first quest, they reported more issues with the GPS than the other two groups. The players of the first two evaluations also had issues with the usability of the interface, while the last group reported no crashes, GPS issues or usability issues, even though the data collected shows that the GPS accuracy was not perfect.

In the second evaluation, one player forgot to change his settings. He was connected to a wireless network instead of a mobile network. This caused him to experience issues with the accuracy and update time of the GPS signal. The player noticed the problem halfway through the evaluation. In hindsight, my game should have had a mechanism for notifying the players if their settings are incorrect.

GPS Issues - Considerations

It is worth to note that the GPS inaccuracy did not have any direct effect on the results of the players in the game, except for the player that failed to reach the evacuation zone in time. It was the fact that the players would have to wait before interacting with game objects on the map that was detrimental to their engagement. Had my game relied more on accurate and fast GPS updates, the impact of the GPS issues would no doubt have been greater, which is something to keep in mind when designing a location-based game. You should design the game with the limitations of today's mobile devices' GPS receivers in mind. If you rely on very accurate locations or on very quick location updates, the game will probably not work as intended.

GPS signal availability and accuracy are worse in areas with many trees or tall buildings, as the GPS receiver is dependent on a clear view of the sky. [Melgard et al., 1994] My evaluations were performed in an area with few obstructions, but players still reported issues with the GPS. When creating a location-based game, you should "place" the game world in an area with as few interfering obstructions as possible, to mitigate the impact of GPS issues.

In the future I would expect mobile devices to be deployed with better batteries and GPS receivers, significantly reducing the issues that one can encounter while developing and playing a location-based game. If the GPS updates happen fast enough and with a precise enough accuracy, truly real-time location-based games can be created, opening up many interesting possibilities in terms of both learning and engagement.

Device Dependency

The multitude of devices available and the many versions of Android available can lead to unexpected issues and crashes. A couple of the players, which were using phones with Android version 4.1 or higher, reported that when changing the orientation from portrait to landscape that information dialogs would reappear. Doing this enough times would cause the game to crash.

If I had distributed the game to people with a wide array of phones before having the first evaluation, it is more likely that this device-dependent bug would have been discovered and fixed before the actual evaluation.

There was also a significant difference in the GPS receivers of the different devices. While some devices, such as the Wildfire S, would almost always have quick and sufficiently accurate updates, others were both slower to update and more inaccurate.

10.1.2 Usability

The players in the first two evaluations reported several issues with the usability, which led me to create a new interface before the last evaluation. There were no reports of issues with the usability of the interface during the last evaluation, with the players stating that they felt it was intuitive and easy to use. The process highlighted several important considerations when creating a user interface for a location-based serious game. The key points are summarized here.

Considerations

1. User interaction should happen only through GUI buttons
2. Important functionality should be easily available
3. Key information should be clearly presented
4. Design with screen size limitations in mind

1: As different mobile devices often come with different setups of hardware buttons, it is important to use a GUI interface. This enables the game to be usable on any device without any configuration. During the second evaluation, one player had to change the settings on the phone to be able to interact with the game, as it used the hardware menu button, which is being phased out by Android and was not available on his phone.

2: A key in creating a user friendly game is to make it easy for the players to access important functionality. Actions, such as placing a sandbag wall

or sending a message, should be easily available. The less buttons the player has to press to accomplish an action the better. You should also consider where you place buttons, as the player would normally have his thumbs in the lower part of the screen. Placing a button at the top makes it more difficult to press it, and obstructs the players view of the screen.

3: Since my game relied on information presented through message dialogs, it was vital that the players read the messages. The feedback of the first two evaluations was that the players would often not read the messages properly, causing them to miss the objective of the quest. This was a problem because the players could not easily redisplay the message dialog. Before the final evaluation I added a help-button to mitigate this issues, which proved to be a good decision. One player mentioned the usefulness of the help-button, as he several times misclicked the OK-button on dialogs before he could read the message.

Another issue in this regard was the glare from the sun, which made it difficult to read the text of the message dialogs. The players also had issues noticing the action bar that displayed vital quest information such as sandbags and the timer. This was not an issue with the new interface, because the timer, sandbags and points were more clearly presented on the screen. The message dialogs were still somewhat difficult to read under direct sunlight, but the ability to redisplay the dialog helped to mitigate the problem.

4: Android devices have a wide array of different screen sizes, which is something you have to consider when designing a game. I developed primarily for a HTC Wildfire S, which has a very small screen size of 3.2 inches. Because of this I had to carefully consider where to place the user interface elements on the screen, as well as adjusting the size of the elements to be easy to use on both small and large screens. The buttons were placed at the bottom, with the information on the top, leaving room for the map in the middle. I also tested the game on a few other devices that had a larger screen size. This seemed to be a good solution, as there were no reports of usability issues for the final evaluation, on any device.

10.2 Sub RQ-1

What can such a game teach the players in terms flood preparedness?

In previous chapters I stated that some of the key qualities in terms of being prepared for a flood were collaboration skills, knowledge of the territory and flood awareness. In this section I discuss to what extent my game managed to teach the players these qualities. I first analyze the feedback on

each quest, before I move on to look at how the game promoted awareness and exploration in general. Collaboration is discussed in **Sub RQ-2**.

10.2.1 Flood Protection

Several of the players mentioned that they did not feel the game sensitized them to the importance of flood protection or the dangers of flooding, but when listening to what they said in the focus group it was apparent that they had actually learned something. This is illustrated by a few of the comments made: *"It made me think about what a good placement of a sandbag wall might be, which is something I've never done before."* and *"I had never thought about using sandbags to protect against a flood before playing the game."* They seemed to be unaware that the game had actually increased their awareness. There was a mismatch between what the players expected the learning outcome of the quest to be, which was how to place sandbags correctly, and the actual learning goal of the quest, which was to sensitize them to the importance of flood protection. In terms of sensitization, it does not matter if the players know how to place sandbags, but rather that they are aware that sandbags can be used to manage a flood.

A reason for this mismatch could be the perceived lack of realism of the quest. One player commented: *"It was a fairly large river bank. It is unrealistic that we would be able to protect the entire area with the limited amount of sandbags that we had."* The lack of realism of the quest is discussed further in the Sub RQ-3-section.

10.2.2 Monitor Territory

The players understood the goal of the quest and how to complete the objectives. They also understood that they were able to start an early evacuation if they found a critical water level. As one player commented: *"We looked at the normal and the current water level and if there was a big difference it meant that a flood was about to arrive."*

When asked if they understood that their performance in the Monitor Territory-quest (an early flood warning) gave them more time in the evacuation-quest, one player answered: *It's logical when you reflect about it after you've played it. But when you're playing it's not that apparent.* He also stated that he felt the focus group discussion was necessary for him to understand the connection. The comment underlines the importance of having a debriefing-phase. A debriefing can promote discussion and reflection, which can increase the learning potential of the game.

10.2.3 Evacuation

The players understood that the evacuation zone was placed where it was due to its high elevation and distance from the river. When asked if they understood what they should do if a real flood warning occurred they answered: *"Get out (of the area)!"* The feedback from the players seemed to suggest that this quest was the most intuitive. This is probably because it is the quest that is most realistic, in the sense that evacuating in real life done in almost the exact same manner, the major difference being that in real life you will most likely not have an exact evacuation zone to run to. One player suggested to make the zone wider, because there were many areas of a similar elevation that were not deemed safe by the game. He felt that this would increase the realism of the quest even further.

10.2.4 Search and Rescue

The main learning goal of the quest was to sensitize the players to the dangers of flooding. A majority of the players answered in the questionnaire that the game was successful in this regard. Regarding the fact he was stuck in the flood, one player commented: *"I don't know if it's bad thing that if you make bad preparations you will most likely die if there's a flood. It's a good lesson."* This indicates that the player learned an important lesson from playing the game.

When asked if they understood the connection between the flood protection-quest and the search and rescue-quest, one player commented: *"I think the level of flooding was based on the flood protection score. If we had been able to protect the area better, we could potentially save even more people."* When I told him that this was the correct interpretation he added: *"I did not get it while we were playing, but when I reflected about it now I understood. I think the way the quests are connected is good, but when I saw the flood was coming, I thought: 'But what was the point of the sandbags then? The flood is coming either way.' I did not really get the true consequences when I was playing."* This comment once again underlines the importance and usefulness of a debriefing-phase. Most of the players did not learn by playing the game alone, but needed the added reflection that the focus group gave them.

One of the players died because he tried to walk into the flood to interact with an NPC that was already dead. He said that he thought he could have saved him. When I asked him if he did not understand that walking into the flood would be a bad idea, he answered: *"Well, when you say it like that... I did not really think too much about it when I did it, but in retrospect it was obviously not a smart decision. It (the fact that he died) made me stay out of*

the flood for the remainder of the quest.” The comment shows that the game sensitized him to the fact that walking into a flooded area could cause him to die, as he refrained from trying to go into the flood to save NPCs after he died the first time.

10.2.5 Flood Awareness In General

A majority of the players said that the game increased their awareness of the dangers of flooding, the importance of flood protection and the importance of an early flood warning, but as discussed in the Flood Protection-subsection, for several of the players there was a mismatch between their perception of learning and what they had actually learned. A few of the players that said that it did not increase their awareness of the dangers of a food, because they already knew of the dangers, but that they thought the game would be useful to teach people that had less awareness. One comment was: *”I think it would be a good activity to have for example for a school in an area with a history of flooding. In the same way that classes learn about first aid, it (increasing flood awareness) could be useful.”*

In the focus group it was apparent that a debriefing would be very useful in terms of added reflection and learning potential. Several of the players stated that the focus group discussion enabled them to learn and that without this post-game reflection the game would not have useful in terms of learning.

For other players playing the game alone was enough to increase their awareness. To them, the fact that the game was location-based had a key impact. This is illustrated by some of the comments made. *”Even though it is not 100% realistic. You get to feel how it is to run, and you have to actually evacuate from the flood. You are down by the river and you are thinking, ‘Maybe there could be an actual flood here’.”* They felt that in terms of flood awareness, a location-based game was more educative than a regular game. *”It has the potential to engage and increases the game’s connection with real life, which I think increases its usefulness in a teaching scenario. Because the closer you are able to connect a game to the player’s real world, the more realistic it is, which can increase the player’s potential for learning.”* One player felt that the link to the real world made it easier for him to learn, because he was actually doing something instead of reading a book.

Debriefing

One of the players, who is a teacher, said that having a briefing before playing the game would be very beneficial in a learning scenario. The other players

agreed that getting more information before playing the game would increase their learning.

But more pressing than a briefing seemed to be the need for a debriefing. This was apparent after hearing the feedback from the players. I reiterate the quote from the Monitor Territory-section in regards to awareness to the dangers of flooding: *It's logical when you reflect about it after you've played it. But when you're playing it's not that apparent.* A proper debriefing could facilitate not only learning but also learning retention. As one player commented: *"We can discuss why we did things and why different things happened in the game. This helps us to learn more and to retain what we learned."*

The focus group discussions had a short session where we went through each quest, and the players felt that this facilitated reflection and learning, but there were no visual presentation of the results to the players. Having a longer more structured debriefing where the players could see what they did in the game, for example on a map, would likely increase the game's potential for learning.

10.2.6 Exploration of the Territory

An important goal of my game was to facilitate exploration of the territory, and in turn increase the player's knowledge of the area. The GPS data collected showed that all the players walked around 2 kilometres during the game session, and that they covered significant parts of the game area. The results seem to indicate that the game is useful in pushing exploration on the players.

One of the players experienced first hand the importance of knowing the territory. *"While I was trying to evacuate, Google maps lured me into a dead end. On the map it showed a path you could take to get to the main road. But there was a 5 meter tall wall blocking it."* When asked if he learned something from this he answered: *"Now I know where not to go if I have to evacuate from this area in real life."* This result shows that the game can be useful in teaching knowledge of an area.

In regards to the feedback from the players, everyone but two answered in the questionnaire that the game had increased their familiarity with the area. The two players that disagreed were already very familiar with the area, as one of them had lived there for two years, while the other had worked there as a postman. They felt that the game had learning potential in this regard if it was played in area they had not been in before. One comment was: *"I think it is very useful if you want to get to know a new area. You are forced to move around and go to places that you otherwise would not."*

In regards to flooding, a few players mentioned that it was useful for learning where to go when evacuating: *"It can educate people on where it is smart to go when a flood arrives, to push them to go to an elevated area."*

10.3 Sub RQ-2

Which mechanisms can be used to improve collaboration skills?

To support the improvement of collaboration skills, a game needs to have gameplay that requires the players to collaborate and it needs to provide tools that allow the players to collaborate.

1. Collaborative Gameplay
2. Provide Tools for Collaboration

10.3.1 Collaborative Gameplay

Three of the four quests were designed to push the players to collaborate. For the Monitor Territory and Search and Rescue-quest, this is accomplished by having too many objectives for a few players to complete in the given time limit. This means that the players will need to coordinate their actions to be successful. For these two quests, the players coordinated mostly by looking at the map and observing the location of other players. The players said that this was sufficient when deciding where to go. One player commented: *"I looked at the position of the others, and went in the opposite direction."* Another added: *"Because we were so few people and had so little time it was pretty obvious what would be smart to do."*

Two players in the final evaluation walked together for the entire game session. Regarding the Search and Rescue-quest, they said that they understood that it would be smarter to spread out, but that the social aspect of walking together and talking was more important than to find all the NPCs. This illustrates the need for having more varied collaborative objectives, where spreading out is not necessarily the best strategy, which allows players to walk together for a more social experience.

In the Flood Protection-quest, the players have to spread their sandbag wall placements along the river. To do this they need to know what a good sandbag placement is and they need to coordinate who goes where. This requires the players to communicate, if one player figures out where it is smart to place sandbags, he should tell the others. From the results of the evaluations it was apparent that the players were not collaborating as much as they should have. Players were communicating face-to-face with others in

their vicinity, but no one were using the messaging functionality to talk to the rest of the group. This caused a divide in the groups where only a few would communicate their strategy with each other, which was a key reason the players did not get a good score. A comment from one of the players illustrates the problem: *"I wanted to place them (the sandbag walls) as close together as possible. I tried to discuss this with another player, but he walked away before I was able to."*

10.3.2 Provide Tools for Collaboration

For the Search and Rescue-quest and the Monitor Territory-quest the results of the players indicate that observing the other players were sufficient to coordinate where to go. During the Flood Protection-quest, some of the players successfully collaborated using face-to-face communication, but several walked alone, completely isolating themselves from the others. The lack of the use of the messaging functionality was a key reason.

Messaging Functionality

The messaging functionality did not seem to have any practical use, as it takes too long to type a message, time the players would rather use to complete quest objectives and move around the area. One player tried to get help from the others by sending a message, *"How do I search a zone?"*, but there were no response from the others. The players said that the lack of time was the reason that they did not use messaging for collaboration. A player commented: *"I did not use it, but I probably should have. The lack of time made it difficult. But I feel the fact that we could communicate is a part of the potential of the game. It is very cool that you can communicate, it makes the game more realistic."* The issue with the messaging functionality is addressed in Section 11.4.

10.4 Sub RQ-3

What is the right balance between fun and learning?

When balancing the fun and learning aspect, a key is to find out what level of realism one can support without affecting the engagement in a negative way. On the other side of the coin, if the focus is too much on the engagement, the realism may suffer, which in turn can reduce the learning potential of the game. From the evaluations I identified several elements that I will discuss in this context.

1. Realism of Quests
2. Time Aspect
3. Physical Aspect

10.4.1 Realism of Quests

For my game, a key in terms of promoting flood preparedness was to provide the players with realistic quests in the context of flooding. As this is a game, it is impossible to create a 100% realistic experience. I had to make decisions of what to put in the game and how to balance the realism and the game elements. For some of the quests, the feedback from the players suggested that the balance was good, but in the Flood Protection-quest, the lack of realism was apparent.

In the Flood Protection-quest, the players were struggling to understand where they should place sandbag walls. They felt it was not intuitive to spread the sandbags along the entire river, due to the limited amount of sandbags they had. Some of the players suggested that this could reduce the learning outcome of the quest, but as the goal of the quest is to sensitize the users to the importance of flood protection, and not teach them the actual procedure, this is unlikely. It is more likely that the lack of realism of the quest can contribute to a loss of engagement, as the players were unable to find a good strategy to do well. This could be the reason that none of the players selected this quest as the most engaging.

One player was questioning the realism of the quest: *"I don't know how realistic the game is, but placing a few sandbags in such a big area, does it make any difference?"* He also felt the game was slightly too unrealistic in regards to material damages not being taken into account, and that this weakens the flood awareness aspect. Having the flood cause material damages in the game would be a good idea, as it would further emphasize the consequences of a flood, and is something that should be considered for future work.

As explored in the Sub RQ1-section, having a debriefing could help increase the learning potential of the game. It can also help with the balance between the learning aspect and the fun aspect. While playing, most players are not aware that they are actually learning, but with a debriefing the players are able to reflect on what they did in the game and what connection the game has to a real life flood.

10.4.2 Time Aspect

I decided to have a time limit on the quests to try to create a feeling of stress, both to mimic the stress felt in a real flood but also to make the game more engaging. I had to keep in mind that the positive stress should outweigh the negative stress, to keep the game engaging rather than frustrating. In this case, if the stress the players feel are too close to the stress they would feel in a real flooding situation, they would not want to play the game as it would be too stressful. If the time limit of a quest is too high, the players would not feel any stress at all, which could ruin both the engagement and the learning aspect of the quest.

A comment from one player could indicate that the game at least partly achieved this balance between the negative and the positive stress: *"The time aspect was motivating, both negatively and positively. It was stressful after while, I didn't really grasp the gravity of the situation at the beginning. I just walked calmly to the crate. And when I was measuring water, suddenly the flood was coming and I had to get out of there and had just a few minutes to do so. This was both stressful and engaging."*

10.4.3 Physical Aspect

For two of the players, the physicality of the evacuation quest was demotivating. They said: *"I don't have the stamina to run."* and *"If I knew I was going to run and did not wear jeans and bring a backpack, I would have made a better effort."* Although the physical aspect was demotivating for them, it illustrates the importance of having good stamina in a real evacuation scenario.

One could reduce the physical requirements of the game by adjusting the time limit according to the players' fitness levels. This would most likely increase the engagement for players in bad shape, as they would be able to participate on the same terms as better trained players. A possibly issue is that it could reduce the sensitization aspect in terms of the importance of being in good shape. By adjusting the difficulty one could also create a greater challenge for the players that are in shape, which is useful if the default quest duration is too high, making the game too easy for them.

It is important to find a middle ground between the realism and the engagement in terms of the difficulty level, because if the game is too easy it can have a negative effect on both engagement and learning, while if it is too difficult it can have a huge negative effect on the engagement, which in turn can affect the learning as well.

10.5 Sub RQ-4

Which mechanisms can be used to promote engagement?

While designing the game I tried to add game mechanics and dynamics that could motivate the players, such as a reward system. From the feedback of the evaluations it was clear that the players liked the game. All the players that played the entire game agreed that the game was engaging. This is also illustrated by comments they made: *"I think it was fun, it was like being at a treasure hunt."* and *"It could be nice as a team building for a company, it would be a fun activity in that setting."*

The players were motivated by different aspects of the game. The main motivating factors are summarized below.

1. Reward System and Leaderboard
2. Time Aspect
3. Physical and Location-Based Aspect

10.5.1 Reward System and Leaderboard

One player mentioned he liked the achievements he got: *"You are now a skilled volunteer"*, and that this motivated him. Another said: *"It was motivating to get points for doing tasks. I knew I had a better score than the others and this motivated me even more."* It was clear from the feedback that having a reward system and leaderboard added to the engagement of the game.

A few of the players felt that having a group-based leaderboard would be better. In the sense that you play together as a group and get a common score, instead of individual scores. As one commented: *"If you were competing against the others, as well as collaborating it would make it even more fun. When you were done you could see who did best."* A solution could be to keep the level system as it is, but base the leaderboard on the group's results instead of individual results.

10.5.2 Time Aspect

As explained in the Sub RQ-3-section of this chapter, a key in creating an engaging experience was balancing the positive and negative stress that is associated with time pressure. From the results of the questionnaires, it was clear that the balance was right, as no players answered that the game was stressful in a way that demotivated them, while the majority of the players

felt the game was stressful in a motivating way. For one player the limited time was the main motivating factor. He commented: *"For my part, the fact that I had limited time was enough to engage me. The fact that you had a timer worked really well, and motivated me instantly to do my best."*

10.5.3 Physical and Location-Based Aspect

A factor that seemed to be a significant in terms of engagement was the nature of the game itself. The fact that you were physically interacting with the game world and were playing outside was a new and exciting experience for the players. Some comments were: *"It made it really fun. Very cool concept that you can go outside and play. You can run and be on the mobile at the same time, and the fact that it is connected with real life increases the engagement."*, *"How the game worked, that you were supposed to move and pick up things. It was a new experience. That you had to do something physical made it more engaging to pick up stuff etc. than if it was a regular game"*

The location-based aspect of the game was not entirely positive, as the players felt that traffic impacted their gameplay experience. Two of the players also commented that they felt the search zones in the Search and Rescue-quest were too big. One player said: *"We had to wait for cars when we tried to get out of the flood zone, because the flood zone was along the road."* While another commented: *"The zones were too big. I thought: 'Am I supposed to go through this entire area and search?' I had to cross traffic as well, which was a bit demotivating.* A third added: *"There is a possibility that a few NPCs died because I didn't get a green man at the crosswalk."* This illustrates the importance of choosing a suitable location for the game world. If the game is placed in an area with traffic or other external factors that can affect the players, it can reduce the immersion and engagement of the players, as in my game, where they were forced to stop their virtual action of searching for NPCs to wait for real cars, before they could continue with the game. Having unreasonably large tasks, such as a large search zone, can cause the players to feel demotivated, especially if they feel that the reward for doing the task is not worth the hassle.

10.6 Main RQ

How can one design a game that promotes citizens' flood preparedness?

The results of the evaluations indicate that the game is useful for promoting flood preparedness. The game allows for exploration of the territory, has collaborative and engaging gameplay, has, for the most part, a good balance between realistic and fun game elements, and provide the players with scenarios that has the potential to increase their awareness.

The main weaknesses that were identified were the messaging functionality, the lack of realism in the Flood Protection-quest, which caused confusion, and the lack of a structured debriefing and briefing session. The speed and accuracy of GPS updates were also identified to be detrimental to the gameplay experience on some devices.

Based on the feedback from the players, research of literature on flood management and preparedness, and reviewing related location-based games, I have identified ten guidelines that can be used to create a design for a location-based game that promotes citizens' flood preparedness:

1. Design with usability in mind
2. Design with GPS issues in mind
3. Allow for exploration of the territory
4. Promote collaborative gameplay
5. Provide the necessary tools for collaboration
6. Create realistic scenarios for sensitization
7. Keep the balance between fun and learning in mind
8. Design engaging gameplay
9. Provide game dynamics and mechanics that increases engagement
10. Choose a suitable area for the game world

This thesis do not claim that this is a complete set of viable guidelines for promoting citizens' flood preparedness, but based on my results I argue that the implications of them are important. I also do not claim that a location-based game is the only type of game that can be used in this context, but the results show that it is a good solution, as it provides a low-cost method of connecting learning to a real territory, which easily can be extended to new area. To identify additional guidelines or strengthen the viability of those identified, further evaluation has to be conducted. As an example, adjusting the physicality of the game to be more suitable for people in bad physical

shape could help make the game more available and engaging, but it could also have a detrimental effect on the sensitization aspect of the game.

Another important finding that was identified was the importance of having a briefing and a debriefing. When designing a game with a serious purpose one should also plan to have corresponding briefing and debriefing sessions to increase potential for reflection, learning and retention.

CHAPTER 11

CONCLUSION

This section reviews the main results and the contributions of the project. A short reflection on the work followed by a section pinpointing future work for improving the project.

11.1 Summary

In this thesis I have investigated how to design a game that promotes citizens' flood preparedness. An analysis of location-based games and theory of flood management and preparedness were used as a basis for a game design for a location-based serious game in this context. I have developed a prototype on the Android platform in order to see if my design was suited for this purpose.

I evaluated the game with three different groups of people. The evaluation included a game session, a questionnaire and a focus group. The results of the evaluations were used together with the related work to identify 10 design guidelines for creating a location-based game for promoting flood preparedness. The design guidelines describe some of the considerations one should make when creating a game for this purpose.

The prototype acts as a proof-of-concept and included elements of exploration, sensitization, and collaborative problem solving to promote citizen's flood preparedness. It uses rewards, a leaderboard and time pressure to drive engagement.

The learning goal was sensitizing the players to the dangers of flooding, flood management and the importance of an early flood warning, as well as to teach them collaboration skills and knowledge of the territory the game was played in. The engagement goal was to create an engaging experience

with the right balance between learning and fun. Results of the evaluations show that the game was successful in promoting flood preparedness, especially in terms of increasing the player's knowledge of the local territory, but that a proper briefing and debriefing session is required to facilitate learning, retention and reflection. An improved tool for communication is needed to enable effective collaboration. The feedback from the players suggest that the game was highly successful in creating an engaging experience.

11.2 Contributions

The work done in this report contributes to the areas identified in Section 1.2: flood preparedness, serious games and location-based games. Contributions are done in the terms of development of a game design that can be used to promote flood preparedness, as well a prototype of a location-based serious game that acts as a proof-of-concept for the design. By analysing other location-based games, and the results of the evaluations of the prototype, I have identified ten guidelines that can be used to create a design for a location-based game that promotes citizens' flood preparedness. In the section on Future Work, future improvements on the work done in this report has been highlighted.

11.3 Reflection on the Work

The main work done in this thesis was in creating a game design and developing a serious location-based game for Android. A group of location-based games were analyzed to determine the considerations I needed to take when creating the game design.

Implementation and testing was challenging due to the nature of the game. I had to actually go outside and walk around to test it. In addition, the game would run perfectly on some devices and versions of Android, while it would crash randomly on others. A significant amount of time was used for locating bugs and fixing them. Implementing algorithms for calculating the flood protection score and if a person was inside the flood or not, also proved to be difficult.

Three evaluations of the game was performed to identify the strengths and weaknesses of the prototype. The results were used together with the related work to create a set of ten design guidelines for location-based game for flood preparedness. A limitation of the evaluation is that it was only performed with a total of 12 people.

When I look back at the first evaluation I realize that testing the game with more people at an earlier stage could have discovered the major synchronization issue, as well as several device dependent bugs. The first two evaluations underlined weaknesses of the user interface in terms of usability, which made me create a new one for the final evaluation. In hindsight I should have prioritized usability more than I did, preferably as early in the design and implementation phase as possible.

Overall, I can look back at the work I did in this thesis with pride. I have worked on an interesting assignment with many challenges, both in terms of creating a game design for a serious game, and in terms of implementation. Challenges that I have learned a lot from. The fact that everyone that played the entire game found it engaging was very satisfying.

11.4 Future Work

As the game was only evaluated with 12 people in total, further evaluations should be conducted to improve the answers to my research questions. I feel that the evaluations I conducted were enough to give an indication of the usefulness and limitations of my game, and I think that further evaluation would show similar results, but it needs to be evaluated with more people to support this claim. The work in this thesis are being summarized into a scientific paper to be submitted for presentation at an international conference on games and learning.¹

11.4.1 Improvements to the Prototype

The improvement to the game what would have the most impact is a new communication tool. I also mention a few other improvements.

A New Communication Tool

To properly enable communication between players who are not physically in the same location, the game needs to have a communication tool that is easier to use than the current functionality. A good solution in terms of usability would be to integrate a Voice over IP-solution.² The technical challenges of implementing such a solution, and the performance costs in terms of battery and data usage means that this would not be practical with the

¹<http://www.galaconf.org/>

²http://en.wikipedia.org/wiki/Voice_over_IP

technology of today's mobile devices. I therefore propose an alternative messaging functionality. Instead of typing messages, the new functionality would allow players to simply click on the map and select pre-defined messages to send to the other players. This would be a simple, low-cost extension of the current functionality that fits well with the time pressure in the game

Other Improvements

The players suggested several specific elements that could improve the game in various ways, such as a group-based leaderboard for promoting collaboration, incorporating material damages to increase realism, which could in turn promote sensitization, and balancing the difficulty to allow unfit people to participate on the same terms as fitter people. Outside of specific game improvements, the usefulness of having a briefing and debriefing was underlined.

11.4.2 Debriefing and Expert Evaluation

By using an expert in crisis management, preferably in flood management, to evaluate the game, one could identify strengths and weaknesses in terms of how the game promotes flood preparedness. It would be especially interesting to look at how the quest information is presented and the potential for improving the tutorial to facilitate learning. The feedback from an expert could be useful in clarifying the information given in the Flood Protection-quest, or change the dynamics of the quest to make it more realistic.

More importantly though, using an expert could be very beneficial in creating a structured debriefing and briefing. He would be able to state what information should be presented to the players and identify key talking points. As stated in the Discussion-chapter, having a proper debriefing would increase the learning potential of the game.

11.4.3 Expanding the Game to New Areas

As the game is currently only set up to be played in a specific area in Trondheim, to be able to use the game in other areas a web-based interface should be created. This interface would allow people to easily extend the game to other areas by placing zones, quest objectives and flooding directly on a map. As it is right now, extending the game is accomplished by manually editing the database and the code, which is time consuming and unintuitive.

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Part I
Appendices

APPENDIX A

ADDITIONAL DESIGN DOCUMENTATION

This chapter contains additional documentation that is linked to the game design.

A.1 Requirements

This chapter lists the different requirements of the game, which were used as a basis when creating the game design. The analysis of location-based games as well as theory on flood management and preparedness were used to identify the requirements. I created three sets of requirements: learning, technical and engagement requirements.

A.1.1 Learning Requirements

The learning requirements describe specific functionality or dynamics that the game needs to support in terms of learning. Each learning requirement is linked to one of the main requirements.

A.1.2 Engagement Requirements

The engagement requirements describe specific functionality or dynamics that should be implemented to engage the players.

ID	Requirement
LR1	The game shall push the players to explore.
LR2	The game shall provide navigation with a map.
LR3	The game shall push collaboration on the players.
LR4	The game shall provide communication functionality.
LR5	The game shall provide a friends list to facilitate collaboration.
LR6	The game shall mimic the dangers of flooding.
LR7	The game shall push realistic flood management scenarios.
LR8	The game shall show the players the consequences of their actions.
LR9	The game shall have a realistic evacuation scenario.

Table A.1: Learning Requirements

ID	Requirement
ER1	The game shall reward the players for correct actions.
ER2	The game shall use a level-system.
ER3	The game shall use a leaderboard.
ER4	The game shall use collaboration to increase engagement.
ER5	The game shall use time pressure to the engage players.
ER6	The game shall provide tasks that varies in difficulty.

Table A.2: Engagement Requirements

ID	Category	Requirement
TR1	GPS	The game shall mitigate the impact of GPS issues.
TR2	Usability	The game shall automatically update the map on action.
TR3	Battery	The game shall consider the limited battery capacity of mobile devices.
TR4	Latency	The game shall not rely on media files sent over the network.
TR5	Latency	The game shall limit the number of database updates.

Table A.3: Technical Requirements

A.1.3 Technical Requirements

The technical requirements describe how the game should be designed to create a frustration-free experience for the players, mainly in terms of mitigating issues. The technical requirements are not linked to a specific requirement as they touch upon the whole system, but they are described in terms of their category.

A.2 Features of Flooded

A location-based game for Android, called Flooded, has been created. The focus of the game was to promote flood preparedness. To accomplish this, the game aimed to increase citizens' awareness of flood dangers and flood management, their knowledge of their local area and their collaboration skills. The game has elements of collaboration, exploration of territory and sensitization in the context of flooding. The game features gameplay that tries to be both engaging and realistic. Listed below are the main features of the game, which are connected to the research questions.

- Sensitization
 - Dangers of flooding
 - Importance of flood protection
 - Importance of territory monitoring/early warning
 - Correct behaviour when a flood warning is given
- Realism
 - Gameplay in the real world

- Quest scenarios based on real flood management theory
- Engagement
 - Quests that require the players to think and move fast
 - Elements from social games such as a simple level system and a leaderboard.
- Collaboration
 - Collaboration in a time-limited/stressful environment
 - Collaborative problem solving on a global map.
 - Collaboration through messaging, face-to-face communication and observation of others.
- Exploration of territory
 - Navigating by using a map with geolocated data.
 - Traversing area to complete tasks

A.3 Reward System

To give the players an extrinsic motivation to play, a simple reward system has been implemented. The reward system is a point-based system where the players are given points for doing correct actions, but can also lose points if they do something they are not supposed to. When the player first starts the game, he has 0 points. Points are used to compare a player's success to other players by using a leaderboard, the more points the better. Points are also used to determine the player's current level. A player levels up when he reaches a certain number of points. The rewards and levels are explored in more detail in the sections below.

A.3.1 Rewards

Players are rewarded for doing quest-related actions and punished for dieing. As an example, submitting a water level gives the player 75 points. The player loses 150 points for not reaching the evacuation zone and for getting caught by the flood in the after-flood phase. Both of these events lead to the player's death, which suspends the player for 1 minute, acting as an extra detriment in addition to the point loss. All the rewards are summarized in the table below. The bonus points for the flood protection is given as a

Quest	Action	Reward
Tutorial	Complete tutorial	100 points
Flood protection	Place sandbag	0-50 points
Flood protection	Bonus points	0-250 points
Monitor territory	Submit water level	75 points
Evacuation quest	Evacuate successfully	75 points
Evacuation quest	Evacuate unsuccessfully	-150 points
Search and Rescue	Caught by flood water	-150 points
Search and Rescue	Finding NPC	50 points
Search and Rescue	Correct notification	50 points

Table A.4: Summary of Quest Rewards

Rank	Points needed
Civilian	0 points
Novice Volunteer	100 points
Volunteer	500 points
Skilled volunteer	1000 points
Expert volunteer	3000 points

Table A.5: Summary of Level System

multiplier of the group's flood protection score. As an example, the players get a score of 100% flood protection, each player is then given $(100/2)*5 = 250$ points. The rewards are summarized in Table A.4.

A.3.2 The Level System

The game uses a level system where the player's current points decide what level he is on. Each level represents a rank. When the players gains a level he is promoted to a new rank. The player starts the game with 0 points and the rank of Civilian. As he gains points he rises in the ranks. The level system does not give the players any advantages, but acts as achievements to add an extra incentive to do well in the game. The ranking system is summarized in the table below and includes the points needed to reach each level. Players will also drop down a rank if they get below the points of their current level, unless they are a mere civilian.

APPENDIX B

ALGORITHMS

This chapter describes a few of the algorithms developed for the game. Some of the algorithms in the game are adapted from similar algorithms found on the internet, while others I have created myself. The algorithm for computing a flood protection score can be seen in the Game Design-chapter.

B.1 Checking to see if a Player is in the Flood

This is a version of the classic Point-in-polygon-algorithm¹, which is adapted to support geographical coordinates, namely latitude and longitude. The algorithm is given in Java code. This is called each time a player moves during the Search and Rescue-quest, for each of the flood zones that comprise the flood.

Listing B.1: Adapted Points In Polygon

```
latLngPointsInPolygon(LatLng positionOfPlayer){
    boolean inside = false;
    double lat = positionOfPlayer.latitude;
    double lon = positionOfPlayer.longitude;

    int i = 0;
    int j = vertices.size() - 1;

    // vertices refer to an ArrayList that holds ↔
    // the vertices
```

¹http://en.wikipedia.org/wiki/Point_in_polygon

```

// of the polygon that represents flood zone.

for (LatLng point : vertices) {
    double lat_i = point.latitude;
    double lon_i = point.longitude;
    double lat_j = vertices.get(j).latitude;
    double lon_j = vertices.get(j).longitude;
    if ( ((lat_i > lat != (lat_j > lat)) &&
        (lon < (lon_j - lon_i) * (lat - lat_i) / (lat_j - lat_i) + lon_i) ) )
        inside = !inside;
    j=i++;
}
return inside;
}

```

B.2 Compute the Distance Between the River and the Sandbag

This algorithm is used to determine the closest distance between a sandbag wall placement and the river. It is used when a player places a sandbag wall to determine the "distance score" of the sandbag. In the game, the river is represented by a set of invisible lines. Finding the closest distance to the river means finding the shortest possible distance to the closest line. To do this I find the Great-circle distance² between the sandbag and the endpoints of all the lines. The lines are small enough to negate the fact that a point between the endpoints could be closer to the sandbag. The closest distance is chosen as the distance to the sandbag. The algorithm is described in Java code.

Listing B.2: Distance to River

```

public double getDistanceToRivers(LatLng sandbag){
    double tempdistance = 0;
    double distance = Double.MAX_VALUE;

    for(RiverLine river: rivers){
        tempdistance = computeDistance(sandbag, river.getStartPoint());
        if (tempdistance < distance){
            distance = tempdistance;
        }
    }
}

```

²http://en.wikipedia.org/wiki/Great-circle_distance

```

        }

        return distance;
    }

    public static double computeDistance(LatLng x, LatLng y){

        double x1 = Math.toRadians(x.latitude);
        double y1 = Math.toRadians(x.longitude);
        double x2 = Math.toRadians(y.latitude);
        double y2 = Math.toRadians(y.longitude);
        double a = Math.pow(Math.sin((x2-x1)/2), 2)
            + Math.cos(x1) * Math.cos(x2) * Math.pow(Math.sin((y2-y1)/2), 2);

        double angle = 2 * Math.asin(Math.min(1, Math.sqrt(a)));
        angle = Math.toDegrees(angle);
        double distance = 60 * angle;

        return distance*1852;
    }
}

```


APPENDIX C

DETAILED TECHNICAL DESCRIPTION

This section explores the main contents of the system in a more detailed way than Chapter 6.

C.1 Activities

The main package, **com.flooded**, contains all the activity classes, which extends the Android Activity class. In Android, an activity is a single, focused thing that the user can do. In other words, they represent the different views of the system.

The Activity class creates a window in which the user interface is placed. An Activity class is initialized with the `onCreate()` method. From the `onCreate()` method, `setContentView()` is called to set the correct user interface. This is done in the same way for all the classes. The subclasses in the diagram correspond to menu choices inside the application. By pressing a button in the menu, the player is taken to a corresponding activity. A more detailed description of how the activities interact is explained in the activity diagram.

C.2 Activity Diagram

The activity diagram in Figure C.1 shows the general flow of the program. After opening the application the player is taken to the welcome screen, implemented in the `SplashActivity` class. In Android, Intents are used to start activities from within other activities. By clicking the welcome screen, an intent is created for the `MainActivity` class and the player is taken to the

main menu. As displayed in the diagram, the player has six menu options from the main menu. ProfileActivity is linked to showing the player’s profile, MapActivity to opening the map where the gameplay takes place, InboxActivity to opening the player’s inbox, LeaderboardActivity to displaying the leaderboard and GameFriendsActivity to display a list of a player’s in-game friends. The player can also opt to log out of the application. From the MapActivity the player can access InboxActivity and GameFriendsActivity. This is done to facilitate easy use of the messaging functionality. When inside an activity the player can go back to previous activities by pressing the back button on their device, the exception being back to the welcome screen, SplashActivity. Figure 5.7 shows a screenshot of the main menu. Every menu choice corresponds to an activity except for "Log out", which logs the player out.

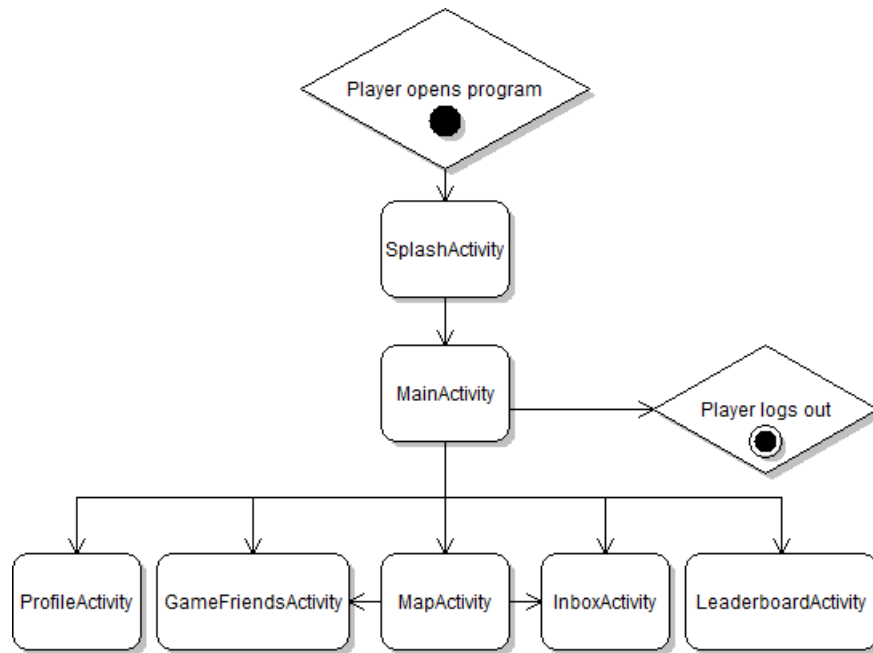


Figure C.1: Activity diagram

C.3 Facebook Implementation

The authentication to Facebook is realized in the MainActivity class. When a player logs in for the first time he must give permissions for the application to use his Facebook data. By doing so the application opens up a new active

session, by calling `Session.openActiveSession()` in the `onCreate()` of `MainActivity`. A `Session.StatusCallback` listener is set up to listen to authentication events. If the log-in is successful, the listener calls `onSessionStateChange()`, which gives `MainActivity` access to the functionality of the Facebook API.

A player only needs to give his permissions the first time he uses the application, for all subsequent uses the application will load the permissions from a local cache.

`GameFriendsActivity` uses the Facebook API to retrieve the player's Facebook friends. This is accomplished by using the currently active Facebook `Session`, which you get by calling `Session.getActiveSession()`, as a parameter when calling `Request.newMyFriendsRequest(session)`. If the request is successful, a list of the player's Facebook friends are returned. The list is then compared to the list of players in the database. If a Facebook friend has authenticated with the game he is added to the list of game friends and subsequently displayed.

C.4 Google Maps Implementation

`MapActivity` extends the `FragmentActivity` class to support use of the Google Maps API. `MapActivity` contains a `GoogleMap` object, which holds the actual map. The `GoogleMap` object contains methods for adding markers and polygons, zooming and panning, and can be used to get the current location of the player.

To be able to get the location of the player, `MapActivity` implements the `OnMyLocationChangeListener` interface. This allows the activity to listen to updates from the device's GPS receiver. By overriding `onMyLocationChange()`, the activity gets access to location updates. The player's location is used when performing quest actions, such as placing sandbags and picking up crates.

C.5 Implementation of Quests

The `com.flooded.quests` package and `com.flooded.gameEntities` package contain the classes that are used to represent quests, quest objects and other game related functionality.

The main class in terms of game logic is the `Quest` class. The `MapActivity` holds one object of `Quest`, called `activeQ`, that represents the currently active quest. `activeQ` is initialized with the player's Facebook id, the activity's context, a `GoogleMap` object and a `Session` object. The `Session` object is used

to hold information about the current game session, such as time started, and is used to determine which quest is currently active.

The Quest object also contains a HUD object and a HTTPHandler object, which are classes used for updating the user interface, and for making calls to the database, respectively. It contains method for starting a countdown, killing and reviving the player, rewarding the player and various helper methods.

Each quest is realized as a subclass of Quest. Tutorial, FloodProtectionQuest, SearchQuest and MonitorQuest contains methods for interacting with the game, while EvacuateQuest contains no interaction. The interactive quests implement their own version of interact(), which is the method that is called when pressing the Interact-button on the screen. They also override Google Map's OnMarkerClickListener to support different type of behaviour when clicking on markers. This is used for picking up crates, measuring water and interacting with NPCs.

When a quest is initialized, a countdown is started. The countdown will last for the duration of the quest, and when it reaches zero the next quest is automatically started. The exceptions are the Tutorial and the SearchQuest. The Tutorial has no time limit, but when it is completed, the player will automatically be pushed into the FloodProtectionQuest. The SearchQuest is the last quest, and as such, when it is finished, the game is over.

Tutorial and FloodProtectionQuest contains Crate object(s) and Sandbag object(s), which are subclasses of QuestObject. A QuestObject is used to hold information about quest objects, which are quest-related objects that are represented by markers on the map.

FloodProtectionQuest also contains a River object, which is used to calculate a sandbag's distance to the river, and RiverZone objects that are used to determine the zone scores. MonitorQuest contains objects of WaterLevel, a subclass of QuestObject, which represents measuring points. EvacuateQuest contains an object of Zone that represents the evacuation zone. SearchQuest contains objects of Zone, which represents the search zones, and objects of NPC, a subclass of QuestObject that represents NPCs. SearchQuest also contains an object of Flooding, which holds the information about the flood, such as magnitude and location of flood zones.

C.6 GCM Implementation

The **PushNotification** package contains the main classes used to support GCM. There is also some functionality within MapActivity and MainActivity.

The ServerUtilities class contains methods for registering and unregister-

ing to GCM. The register method is called withing MainActivity the first time the player opens the game. This creates a HTTP request that is sent to the server. The server stores the device's GCM registration id, which is used when the server sends a message, in the database.

The `GCMIntentService` class contains functionality for receiving messages and creating notifications. When the server sends a message to a device it is broadcasted to the activities that listen to the messages through a `BroadcastReceiver`, in this case the `MainActivity` and `MapActivity`. Regular messages sent between the players are displayed instantly in the `MapActivity` and `MainActivity` view. Quest related messages sent by the server when a update happens is analyzed in `MapActivity` and the appropriate action is taken. As an example, if a new sandbag wall is placed by another player, the message will contain its location and it will be placed on the player's map as well.

The other classes in the **PushNotification** package are helper classes that facilitate the use of GCM. On the server side the GCM functionality is contained in PHP scripts. There are PHP-scripts for registering and unregistering players, and for sending messages.

C.7 Additional Classes

The `com.JSONParser` package contains the classes used in the JSON parsing process. `PlayerHolder`, `QuestHolder`, `MessageHolder`, `SessionHolder` and `ZoneHolder` holds respectively player, quest, message, session and zone data fetched from the database. `PlayerResponse`, `QuestResponse`, `MessageResponse`, `SesionResponse` and `ZoneResponse` hold array lists of `PlayerHolder`, `QuestHolder`, `MessageHolder`, `SessionHolder` and `ZoneHolder`, and are used when transforming the JSON data to Java objects.

The `com.flooded.helperClasses` package contains a number of helper classes. There is also a few private helper classes contained within other classes. The `FriendListAdapter` class is used inside `GameFriendsActivity` to properly fill the list view with friends' Facebook names and profile pictures. `ImageLoadData` and `FriendListItem` is also used in this process. In addition there is a few private helper classes used to display loading boxes while downloading data from the database, as well as a `CancelListener` class to cancel loading boxes. The `Dialog` and `Helper` class are used for displaying messages on the screen.

C.8 Client/Server Communication

The client and the server communicates in two ways. Either the client, which is the player's device, sends a request to the server to do something or the server sends data to the client. Requests are done through HTTP requests, while the server sends data either through HTTP replies or by using GCM. I will illustrate this with an example for both cases.

In the first example, the player has requested data containing the zones from the server, by issuing a HTTP GET request. The server fetches the data from the database using a MySQL SELECT-query, and puts the data in a JSON structure. The server responds to the user by sending the data as a HTTP reply, which can be seen below.

Listing C.1: A JSON data structure

```
{ "data": [ { "zoneid": "1", "notified": "1", "npcfound": "1" },  
  { "zoneid": "2", "notified": "0", "npcfound": "0" },  
  { "zoneid": "3", "notified": "0", "npcfound": "0" },  
  { "zoneid": "4", "notified": "0", "npcfound": "0" } ] }
```

The client then reads the response and uses the Gson library to convert the JSON data to Java objects. In this case the data is saved into an ArrayList of ZoneHolder objects, contained in the ZoneResponse object. By the end of the process, the content of each zone in the database has been put into their own ZoneHolder objects. The ZoneHolder class is shown below. As you can see, the Strings in the class corresponds to the fields in the JSON data from the HTTP reply.

Listing C.2: The ZoneHolder class

```
public class ZoneHolder {  
    String zoneid;  
    String npcfound;  
    String notified;  
  
    public ZoneHolder() {  
        this.zoneid = "";  
        this.npcfound = "";  
        this.notified = "";  
    }  
    public String getZoneid() {  
        return zoneid;  
    }  
    public String getNpcfound() {  
        return npcfound;  
    }  
}
```

```
}  
public String getNotified() {  
    return notified;  
}  
}
```

In the other example, the player has placed a sandbag wall at his location. He sends a HTTP request to the server containing the location of the sandbag wall. The server inserts the data into the database using a MySQL INSERT-query.

In addition the server sends a message to all the other devices registered with the application. This is done by sending a message to GCM servers containing the informaton about the sandbag wall. Google then enqueues and stores the message in case the device is offline. When the device is online, Google sends the message to the device. On the device, the system broadcasts the message to the application. The game processes the message and the sandbag wall is placed on the map.