Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Information Technology and Electrical Engineering
Department of Computer Science

Evelyn Saxegaard

CITY: An Informative Serious Game to Raise Girls' Awareness of IT

Master's thesis in Computer Science
Supervisor: Professor Monica Divitini
May 2019

NTNU
Norwegian University of
Science and Technology

Evelyn Saxegaard

CITY: An Informative Serious Game to Raise Girls' Awareness of IT

Master's thesis in Computer Science
Supervisor: Professor Monica Divitini
May 2019

Norwegian University of Science and Technology
Faculty of Information Technology and Electrical Engineering
Department of Computer Science

Abstract

Technology and innovation are key elements in the development of today's society, and they continue to strive towards the best possible future. They evolve and reveal new needs, quickly becoming the most in-demand professions. Although the need for people with this experience rises, there is a significant under-representation of females considering technology as a career option or already working within the field. The missing women in technology have long been a topic of interest and several factors have been revealed to contribute to the existing gender gap. Advocates have long tried to underline the importance of the inclusion of girls and females in IT, and several countermeasures have been taken to increase their interest.

This thesis examines the challenging question of the under-representation of females in IT and investigates the use of an informative serious game as a counter step. The focus is on identifying which game mechanics work well, both in terms of generating engagement and raising awareness. This is done by conducting a study on the state of the art literature on game design and the existing gender gap in games, and through the design and development of the informative serious game CITY aimed at raising the player's awareness of IT. The game has been evaluated in an iterative process, including participants from the target group, game experts, teachers, and NTNU students.

The result of this research is an examination of the potential of using informative serious games to increase awareness of IT. It presents the accompanying game mechanics that were detected to work best for generating engagement and learning outcome in the player. Consequential play, real-life scenarios, and conversations with other game characters were revealed as the most effective mechanisms to raise the player's knowledge. The game presented in this thesis focuses on making information about IT available, but by utilising the findings in this research, other effective informative serious games could be developed to accommodate other topics.

The game CITY is available at `https://techinthecity.firebaseapp.com`.

Sammendrag

Teknologi og innovasjon er sentrale elementer i utviklingen av dagens samfunn, og de fortsetter å streve etter den best tenkelige framtiden. De utvikler og avslører nye behov, og har raskt blitt noen av de mest ettertraktede yrkene. Selv om behovet for folk med denne kompetansen øker, er det en betydelig underrepresentasjon av kvinner som vurderer det som et karrierealternativ eller som jobber innenfor det allerede. De manglende kvinnene i teknologi har lenge vært et debattert tema, og flere faktorer har blitt avslørt for å bidra til den eksisterende kjønnsforskjellen. Talsmenn har lenge prøvd å understreke betydningen av å inkludere jenter og kvinner i IT, og flere tiltak har blitt satt i gang for å øke interessen deres.

Denne masteren undersøker det utfordrende spørsmålet om underrepresenteringen av kvinner i IT, og om et informativt serious game kan virke som et mottiltak. Fokuset har vært på å identifisere hvilke spillelementer som fungerer godt, både til å generere engasjement og øke bevissthet. Dette gjøres ved å utføre en studie av relevant litteratur om spilldesign og det eksisterende kjønnsskille i spill. Dette blir også undersøkt gjennom utviklingen av det informative spillet CITY som ønsker å øke spillerens kunnskap om IT. Spillet har blitt evaluert gjennom en iterativ prosess som inkluderer deltagere fra målgruppen, spilleksperter, lærere og studenter ved NTNU.

Resultatet av denne forskningen er en undersøkelse av potensialet informative serious games har til å øke bevisstheten rundt IT. De tilhørende spillelementene som ble identifisert til å virke best til både å skape engasjement og gi godt læringsutbytte er presentert. Det ble avslørt at muligheten til å ta valg, bruk av relaterbare situasjoner, og samtaler med spillkarakterer var de mest effektive mekanismene for å øke spillerens kunnskap. Spillet som presenteres i denne oppgaven fokuserer på å gjøre informasjon om IT tilgjengelig, men ved å utnytte funnene fra denne forskningen, kan andre effektive informasjonsspill utarbeides for å imøtekomme andre temaer.

Spillet CITY er tilgjengelig på `https://techinthecity.firebaseapp.com`.

Acknowledgements

I would first like to thank my supervisor Monica Divitini for her invaluable guidance and motivation throughout the process of this research. She help steer me in the right direction and provided me with an insight into the world of research. I am grateful for her expertise and network that provided me with the necessary resources to conduct this research.

I would also like to thank the experts, teachers, and NTNU students involved in evaluating the informative serious game CITY.

Additionally, I would like to express my gratitude to the secondary school students who used their valuable time to participate in the evaluation of the game.

Trondheim, May 2019

Contents

List of Figures

List of Tables

Acronyms

DSR Design Science Research

IDI Department of Computer Science

IGCW Information Game Co-Design Workshop

IT Information Technology

NTNU Norwegian University of Science and Technology

STEM Science, Technology, Engineering and Mathematics

TGPA The Girl Project Ada

Chapter 1

Introduction

1.1 Motivation

Information technology (IT) is a key element in the development of society and play a role in almost all areas of civilisation today. It affect how climate change is addressed, how healthcare is advanced, and how daily life is made easier. IT continues to evolve and reveal new needs and has quickly become one of the most in-demand professions (DAMVAD, 2014). Although the need for people with this experience rises, there is a significant underrepresentation of females considering it as a career option or already working within the field.

The missing women in science, technology, engineering, and mathematics (STEM) have long been a topic of interest (Beede et al., 2011). Diversity in the workforce is essential for effectuating innovative environment, productivity, and creativity (Corbett, 2015). By failing to address this issue in an appropriate manner, we are accepting the exclusion of half the world's population from making a contribution to these fields (*The Consequences of Excluding Women in Science,* 2016). Advocates have long tried to underline the importance of the inclusion of girls and females in STEM, and several countermeasures have been taken to increase their interest (*Lær Kidsa Koding*; *Jenter Koder*; *Girls in Tech*; *Girls Who Code*). Nevertheless, many of these activities are aimed at young children and tend to have higher attendance by boys, thus leaving teenagers and girls out.

The gender gap is a collection of global problems where prominent factors are stereotypes, missing awareness, lack of role models, and the view on girls' abilities (Hill, Corbett, and St. Rose, 2010; Kahn and Ginther, 2017). Since Marie Curie won the Nobel Prize in physics in 1903, only 20 women

have followed in her footsteps and won within the areas of physics, chemistry or medicine opposed to 585 men (*Nobel Prize awarded women*; *Facts on the Nobel Prize in Physics*; *Facts on the Nobel Prize in Chemistry*; *Facts on the Nobel Prize in Physiology or Medicine*). The lack of female representatives in technology and other STEM-areas constitutes a negative cycle that aid to discourage other women from seeking these opportunities (Watkins, 2018). Their absence results in a shortfall of role models, inspiration, and support.

This thesis examines the challenging question of the under-representation of females in IT and investigates the use of an informative serious game as a counter step. Previous research has revealed that girls are introduced to few opportunities to procure information about IT, what it is and why it is relevant to them (Parker, 2018; Ashcraft et al., 2012; Saxegaard, 2018; Serussi, 2017). Consequently, their missing awareness is resulting in a decrease in interest. The aim of this research is therefore, to explore the use of an accessible and engaging medium for presenting information to young adults, namely a serious game.

Games have long been seen as an effective and motivating tool to improve learning outcome (Girard, Ecalle, and Magnan, 2013), and serious games have further enhanced this effect. In contrast to regular games aimed at entertaining the player, serious games have the additional agenda of being educational. They consist of a serious aspect targeted towards enlightening or raising awareness of a subject. Several studies have described the results of using such games as effective both in concerns to motivation and learning outcome (Wouters et al., 2013).

This thesis will therefore focus on the use of serious games to present information about technology and the impact it can have on society to help raise awareness of the issue regarding the under-representation of females in IT. It will also identify motivating learning and game elements that are central and helpful when developing an informative serious game.

1.2 Context

This study has been done at of the Department of Computer Science at the Norwegian University of Science and Technology. It continues the previous work from the specialisation project (Saxegaard, 2018) with the focus of analysing girls' perception of IT and how to enhance their interest in the

subject. This research looks at the use of serious games for presenting information and raising awareness about IT.

The project is aimed at students in secondary school, as previous research has revealed that the gender gap beings to evolve at school and continues to grow as they age. Reaching them as early as possible is therefore considered imperative to inspire more girls to become interested in IT. This research might therefore be useful when considering the elective programming subject in lower secondary school. It can be utilised before the selection of the elective subject to give the students insight into the true nature of technology and programming.

1.3 Research Questions

This study investigates if secondary school girls will become more interested in IT after having played an informative serious game. The term "informative serious game" describes a digital game-based learning system utilising information as its main learning mechanism to raise the player's awareness of a certain issue.

The use of serious games are widespread and have been utilised in several contexts (Mouaheb et al., 2012; Calderón and Ruiz, 2015; Spangenberger et al., 2018), making it reasonable to assume that it would be appropriate and efficient to use as a mechanism for educating and motivating girls to see IT as an interesting topic. The research questions therefore look at how to design serious games for presenting information to raise girls' awareness of technology and programming.

> **RQ1:** How can an informative serious game be designed to raise girls' awareness of IT?
>
> **RQ1.1:** How can engagement elements be used to raise awareness of IT when designing the informative serious game?
>
> **RQ1.2:** How can learning elements be used to raise awareness of IT when designing the informative serious game?

1.4 Research Methods

Design science research (DSR) was chosen as the methodology of choice for this study. It was selected based on its analytical technique to complement positivist, interpretive, and critical perspectives, and its guidelines for evaluation in research on information system (Hevner et al., 2004; Vaishnavi, Kuechler, and Petter, 2004). The two primary characteristics of the method are (1) creating new and innovative artefacts and (2) analysing the use and performance of existing artefacts. Common artefacts designed using DSR include algorithms, user interfaces, and programming languages.

The methodology seeks to extend the boundaries of existing research and utilises three overlapping cycles to do so. These are the relevance, design, and rigour cycle. The relevance cycle facilitates the discovery of requirements and acceptance criteria for the evaluation of the final results. The rigour cycle adds information and results in the projects knowledge base and ensures the artefact's innovative value. The third cycle, the design cycle, is an iterative process of creating and evaluating the artefact. The end result is an artefact created to solve a practical problem. It is grounded on theories and a conceptual framework generated by an iterative process of assessment and re-design (Morschheuser, Maedche, and Walter, 2017).

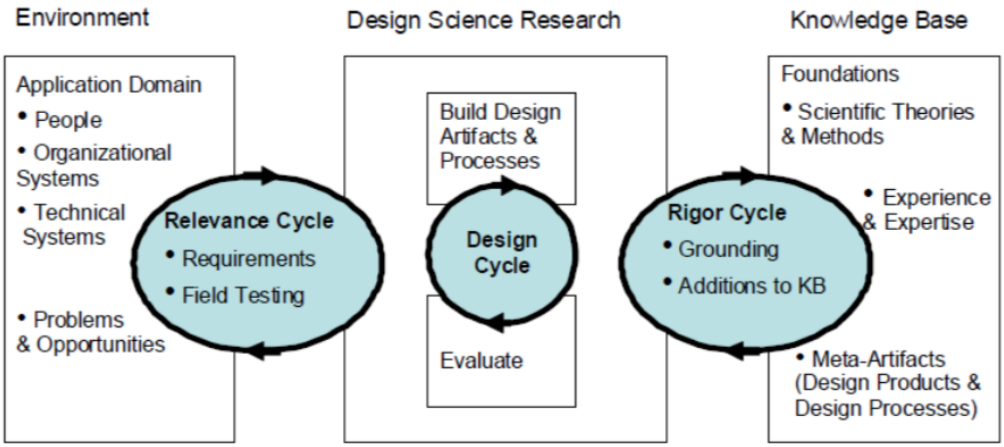


FIGURE 1.1: Representation of the Design Science Research cycles. From (Hevner, 2007)

This thesis builds on a specialisation project that explored how serious games could be used to increase girls' awareness of IT (Saxegaard, 2018). This research was facilitated around the relevance and rigour cycle. It laid the foundation for identifying the needed specifications and assessment criteria for

the serious game, as well as it incorporated relevant literature and theories to the knowledge base. This foregoing contribution to the project has resulted in a transition during the current phase where the design of the artefact has become a more significant part of the research. The game design proposed in this thesis is a product of the findings in the specialisation project and seeks to expand on today's knowledge of informative serious games and the gender gap in IT.

To answer the research questions and contribute to the conceptual framework of this thesis, several data collecting activities are conducted. To acquire a deeper understanding of game design and gender in games, a section on the state of the art literature is presented in Chapter 3. Before the development of the intended informative serious game, a game design is proposed and tested. The outcome is used to create a digital prototype. The design process is an iterative procedure with several participating groups partaking in evaluating the game. The first iteration will be an expert evaluation with game experts, a pedagogy expert, and a participant from the target group. In the later iteration, the assessment will be conducted with the target group, teachers, game experts, and a representative from The Girl Project Ada. Figure 1.2 provides an organised overview of the different game versions described and evaluated in their respective chapters.

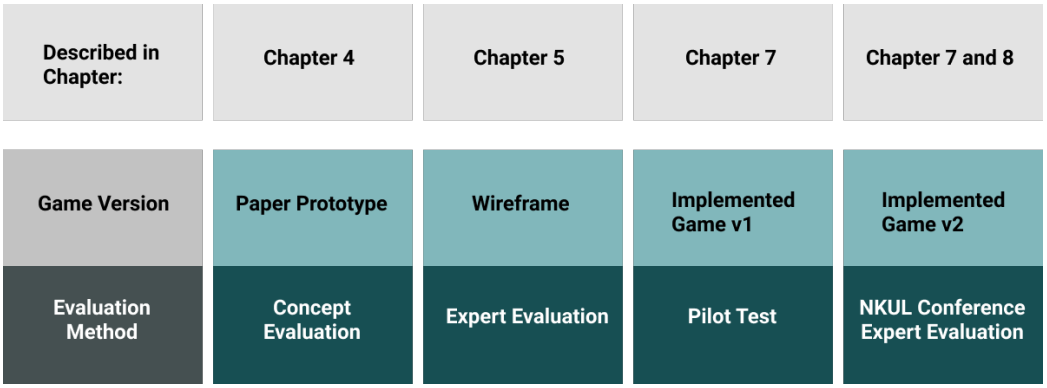


FIGURE 1.2: A timeline visualising the different versions of the game and corresponding evaluations

Several methods are used to collect data; interviews, group discussions, questionnaires, and observations. This will result in qualitative and quantitative data to be analysed.

1.5 Results

The outcome of this study contributes to the field of informative serious games for raising awareness of IT in several ways: a game design, a set of engagement and awareness raising game elements that work well in informative serious games, and a prototype of the game CITY. The results are acquired from a review of related work, evaluations of the concept, and two more evaluations of the digital prototype.

The examination of the state of the art literature presents previous efforts on serious games to gain insight into the approach and methods of creating an effective information game. The result is a classification of engagement elements and awareness raising objectives that are satisfactory in serious games for presenting information. Furthermore, the review provides insight into serious games specifically designed for females. The end result is a systemised mapping of general informative serious game elements and game mechanics that females prefer.

These findings, as well as the outcome of previous research, result in the game design for the serious game CITY. The specialisation project revealed that female secondary school students have missing knowledge about what technology and programming is and how it affects them. The game is therefore created to raise this audiences' awareness of IT and the value it holds, seeking to increase their interest in the subject. The game is available online at `https://techinthecity.firebaseapp.com/`.

The final contribution of this research is the results from the evaluations of CITY. The outcome suggests that informative serious games have the potential to increase awareness of IT. This leads to the assumption that they can be utilised to raise knowledge of other topics as well.

1.6 Outline

Chapter 2 provides a description of the research problem and addresses the factors of the under-representation of females in STEM and IT in more detail. Chapter 3 examines related literature on game design and the existing gender gap in games. It aims at identifying game elements best suited for informative serious games.

In Chapter 4, a presentation of the informative serious game CITY is given. It provides insight into the game's storyline and the first assessment of the game concept. Chapter 5 discusses the first iteration of the game, describing the expert evaluation.

Chapter 6 is a technical description of the game, elaborating on the used technologies, frameworks, and system architecture. In Chapter 7, the first phase of the final iteration is presented, focusing on the evaluation during the NKUL conference. Chapter 8 elaborates on the second phase of the final evaluation of the digital game with experts and the target group.

Finally, a discussion of the results and their implications are given in Chapter 9, whereas a conclusion of the research is presented in Chapter 10.

Chapter 2

Problem Description

We surround ourselves with technology and the digital world in almost all aspects of our lives and to be able to take advantage of this new technology we must allow for talent and unique qualities to shine through. The need for people with experience and knowledge in these fields continues to rise (DAMVAD, 2014) and the contribution by both men and women is fundamental for the process of societal and economic transformation (Lacey and Wright, 2009). Nevertheless, the number of women in these disciplines remain low, resulting in a tangible loss in skill set, innovative ideas and alternative perspectives (*Girls in STEM*, 2017).

Technology is a crucial part of the world's innovative achievements and global enhancements, and today's society is becoming increasingly more dependent on it. We rely on a human expertise equipped with the knowledge to utilise digital tools, thus the deprivation of women with this talent is something the world cannot afford to lose (*The Consequences of Excluding Women in Science*, 2016). Research has revealed that gender-balanced groups have heightened collective intellect with the potential of greater innovative results compared to groups consisting only of either men or women (Catalyst, 2013; Woolley et al., 2010).

The research conducted in this thesis seeks to investigate the low numbers of females in IT. It aims at challenging this problem by exploring the possibility of using serious games to increase peoples awareness of the topic. Since technology is a central part of STEM, it was seen as beneficial to analyse literature that embraces both fields. The problems related to the female underrepresentation in STEM are homogeneous to those found in technology areas. By exploring both sides, a more dynamic and comprehensive image of the issue can be formed.

2.1 Factors

There are several factors associated with the under-representation of women in science and technology. (1) Missing knowledge and opportunity to participate in activities aimed at increasing their interest, (2) bias about girls' abilities and interests, (3) girls' self-assessment of their own capabilities, and (4) stereotypes about the technological societal environment (Hill, Corbett, and St. Rose, 2010).

2.1.1 Missing Knowledge

In research prior to this thesis, interviews were conducted to investigate the type of information secondary school girls are given about IT. The conversations also consisted of inquiring about their interest in technology and whether or not they had participated in activities or lectures aimed at increasing their knowledge about it. The interviews exposed that secondary school girls have limited opportunities to acquire general information about what IT is and how it can be used.

Theme	**Description**
Motivation and Interest	Missing interest
Beliefs and Personal Experience	View programming as boring, difficult, but something everyone with an interest can do
Participation in Programming Activities	None of the upper secondary school students have had the opportunity
Missing Information	Know very little about the topic
Misconceptions	Gap between the students' perception and the IDI ambassadors'

TABLE 2.1: Summarised interview results for the specialisation project

Similar results have been found in other studies (Parker, 2018; Ashcraft et al., 2012; Serussi, 2017). Serussi, 2018 explored this theory in a series of interviews with secondary school students, which mapped and analysed their perception and awareness of programming and technology. Their answers

were contradicting, where 85,6% told the interviewer that they knew what programming meant, but only 27,4% had an understanding of what an algorithm was. Some thought that designing a PowerPoint presentation was programming.

In PwC's The Women in Tech-report, it was stated that "*Females aren't considering technology careers as they aren't given enough information on what working in the sector involves and also because no one is putting it forward as an option to them*" (PwC, 2017). Their research showed that the gap begins already in school and continues to grow as they get older. Misunderstandings and misconceptions about what the field is, divert young girls from the path of technology (Bach, 2016; Cheryan et al., 2017). The Women in Tech-report suggests starting as early as possible as this is the best time to educate and inspire girls to seek technological interests.

2.1.2 Negative Bias Toward Girls' Abilities and Interests

The report "Why so few" by Hill, Corbett, and St.Rose (2010) draws on an extensive and diverse body of research on the topic of under-representation of females in science and engineering. They describe how societal beliefs and the environment we learn in, affect the interest and achievements girls exhibit in these subjects. Other findings have demonstrated that by encouraging girls to believe their intelligence can grow with learning and education, parents and teachers are increasing the chances of these girls doing well in mathematics (Correll, 2004). Believing in the potential of these girls increases their self-confidence and improves their learning outcome, resulting in better tests results and enhances the chance of them pursuing mathematics in the future (Dweck, 2007). Although this is true for all students, it is especially accurate for girls, because of the existing negative stereotypes about their abilities (Ertl, Luttenberger, and Paechter, 2017).

The presence of stereotypes towards girls' abilities and performance in STEM can negatively affect the way they see themselves, their test results and their aspiration for pursuing engineering and science later (Correll, 2004). Despite reports on girls' capabilities in mathematics, where a meta-analysis on gender roles exposed that girls exceed boys in primary school, they continue to be underestimated (Wouters et al., 2013). This could partly be connected to the idea that science and mathematics are associated with the male, while females are affiliated with humanities and arts (Cai et al., 2016).

This type of implicit bias is common, even among those who renounce stereotypes. These unconscious, negative associations can have consequences, girls not pursuing STEM being one of them. In order to change these misconceptions, we need to become aware of the unconscious beliefs we hold (Moss-Racusin et al., 2018).

2.1.3 Girls' Self-Assessment of Own Capabilities

Another cultural factor that influences girls' interest in science and IT is their self-assessment and how they view their own abilities. Studies have shown that they appraise their capabilities in mathematics lower than boys (Samuelsson and Samuelsson, 2016). Furthermore, they believe their performance need to be outstanding to succeed in these "male-dominated" fields (Correll, 2004). Research done by Pajares (2005) demonstrates that the difference in self-confidence related to STEM subjects start as early as middle school and continue to expand throughout high school and college. However, when previous achievements and opportunities to learn are controlled, the difference in the confidence-gap disappears (Zimmerman and Martinez-Pons, 1990; Lent, Brown, and Larkin, 1986; Hill, Corbett, and St. Rose, 2010).

By looking at students that exhibit a lack in confidence related to maths or science, it becomes more and more challenging to motivate them to use and develop those skills as they are more likely to give up when facing a problem (Dubach, 2018). Without the ability to believe that a science and technology related task is solvable, people are more inclined to put it aside in favour of something easier.

2.1.4 Stereotypes about the Technological Societal Environment

Even though we know that most stereotypes are inaccurate and over-proportioned, we unconsciously continue to believe that they are true. The powerful force of cultural typecasting is another well-established aspect of why girls choose other pathways than science and technology (Kerkhoven et al., 2016). Two main stereotypes exist that are relevant in the reasoning as to why young girls are driven away from STEM. The first being the culture, while the second is the notion that boys do better in maths (Hill, Corbett, and St. Rose, 2010), which is described in section 2.1.2.

If we look at the culture in IT and ask: who can work in IT and what do they do? One image that pops into many heads is a nerdy guy sitting by himself and writing code. This idea that IT is for boys is part of the reason girls think they do not belong in courses that teach it (Adya and Kaiser, 2005). A study where boys and girls were shown two different computer science classrooms, one with stereotypical design, such as science fiction posters on the wall, and another with images of art and nature, revealed that girls are three times more likely to want to study computer science in a non-stereotypical classroom (Master, Cheryan, and Meltzoff, 2016). By displaying a broader picture of what computer science is and can be, we could be able to increase the interest of more girls.

Social belonging is also a term related to the existence of IT related stereotypes. It is a human tendency to seek towards those we would fit in with and feel connected to (Gjersoe, 2018). As a result, we tend to select environments where we find more of our own gender. Since IT is perceived as male-dominated (Staiger, n.d.), fewer girls feel assured enough to gain interest in it to proceed it. Another aspect associated with this is the idea that we select careers where we believe we can succeed (Bandura, 1977). As previous studies have revealed, we know that girls have on average lower self-confidence when it comes to their abilities and performance in STEM than boys (Correll, 2001). Their discouragement and low numbers are a result of societal beliefs and prejudice against them, hindering them in seeking careers in these fields.

2.2 Informative Serious Games

In a research project preceding this thesis, a systematic literature review was conducted to investigate earlier studies on the subject of informative serious games and to position this work in the existing literature. The process of examining previous work and outlining the research problem enables us to analyse the relationship between each study and help us distinguish the various methods of comprehending it (Labaree, 2018). This allows us to expose possible gaps in today's literature.

The systematic literature review focused on serious games for presenting information. Several studies have already been conducted on games for learning and the use of games in education (Boyle et al., 2016; Bourgonjon

et al., 2011; Guillén-Nieto and Alesón-Carbonell, 2012), however, a comprehensive examination on the use of information as a dominant game feature was scarce. Consequently, the search resulted in the realisation that there is a notable gap in the literature related to informative games. The goal of the review had been to gain a deeper understanding of games that did not necessarily concentrate on learning characteristics, but on presenting the player with information to raise their awareness of a topic. The search was therefore widened to include and explore awareness raising as well.

2.2.1 Increasing Awareness with Serious Games

The studies analysed in the evaluation showed promising results regarding serious games being used to raise awareness. The exhibited effects related to the player becoming more aware of the topic by playing the games, however, several noted that although the effect was present, it did not necessarily mean serious games exceeded traditional training. Nevertheless, people enjoy playing games more than passively receiving information (Gee, 2003), and actions can be taken to increase the outcome and effectiveness of games, by for instance, including a teacher while playing.

An advantage of using serious games to raise awareness is the ease of arranging situations that in the real world would be costly, time-consuming, and maybe even dangerous. This possibility of facilitating and creating controlled situation enables the player to gain more experience and competence in a safe setting (Plechawska-Wojcik and Robaczewska, 2015). Serious games can be used to "*leverage the power of computer games to captivate and engage players for a specific purpose such as to develop new knowledge or skills*" (Corti, 2006).

Most research on building awareness and behaviour change has been carried out in the field of healthcare (Wattanasoontorn et al., 2013; Miltenburg, 2014). These types of games are designed to capture the player while striving to change certain attitudes they have towards their own health. There have been several studies that have demonstrated positive results when looking at behaviour changes in health-related gameplay (Baranowski et al., 2008). 4 out of 6 articles reviewed in the previous literature review was reporting on serious games in the health domain.

A problem related to awareness raising serious games is that to increase people's knowledge and awareness of societal issues, a solid underpinning

needs to be in place. An issue such as the low numbers of females in IT would require a careful design process founded on strong pedagogical values (Rebolledo-Mendez et al., 2009). Including pedagogical components that help guide the player through a structured game-based learning situation may help support the player's development of a knowledgeable opinion on the matter.

2.2.2 Presenting Information through Serious Games

Although awareness raising games were more prominent in the literature, information presented through games was seen as a feature in some of the case studies explored in the review. The games PROCEE (Cosma et al., 2016), NutritionRush (Baranyi et al., 2017), and RebEarth (Ali et al., 2017) all utilised information as an important tool throughout the gameplay to increase the players' knowledge about the topic at hand.

PROCEE is designed to raise awareness of prostate cancer in the especially at-risk group, African Caribbean men. It attempts to incorporate the player's personal details with engaging game elements to provide feedback on whether or not they have symptoms that match the disease. The game's primary goal is to encourage symptomatic men to seek medical help based on the results given by a question-answer feature in the game. Based on this rule-based game system, an evaluation is presented to the player instructing him on what to do next. Information in PROCEE is presented in a non-threatening environment that is intended to calm the player and provide a safe space to answer questions about himself.

NutritionRush was created to heighten the awareness of people's nutritional intake and the danger of malnutrition. The game is different from the other information relevant systems analysed, as it does not rely on information as actively in the gameplay as the others, but rather later in the form of a manual that contains nutritional content and facts. In the active gameplay, the user plays a Mario-like character that is situated in platform-based surroundings with the object of collecting various types of food.

RebEarth introduces an alternative method for agricultural activities, namely the hydroponic system. To make the player acquainted with the method, he

or she needs to seek out the parts needed to build the system unlocking information about each component. This information can be used to teach the player about agriculture, how the parts work, and how the system operates.

The result of the analysis of these information utilising games demonstrates the value information can have in serious games for raising awareness. All three studies reported good results suggesting that the use of information can be an effective tool to make players more aware of the subject presented.

Game Elements Found in Awareness Raising Games

The literature review also investigated the type of game mechanics found in serious games for raising awareness. Both learning elements and game elements are important to take into account, as the player's educational experience is supported by fun and engaging activities. However, balancing learning and fun might prove more challenging in games intended to increase awareness and provide information, as informative serious games might struggle to present information without being tedious.

A systematic analysis of common game mechanics was therefore included in the literature review, and the results can be found in table 2.2. Quizzes and active game tasks, such as collecting items or controlling the character, was among the most common mechanisms. In the studies by Cosma et al. (2016), Luz et al. (2014), and many of the mentioned games in the literature review by Mortara et al. (2014), they used question and answer-based exercises to make the player more aware of the consequences of a decision or to improve their knowledge about a topic.

An engaging and entertaining element that was used in several of the analysed serious games was the mechanism of being able to control the main character and collect items or escape enemies. Furthermore, it was revealed that storytelling and choice-driven elements were popularly used to compel the player to feel an affiliation to the plot and the game. Stories grounded in the subject of the serious game are often used to combine the serious content with the game's entertaining side (Kampa, Haake, and Burelli, 2016). This ensures that the player sees the game as a meaningful activity that, at the same time, facilitates a constructive learning environment. Engaging elements in a serious game establishes a setting where the player does not simply receive information passively but acquire it in an active and motivational manner.

Game	**Game Feature**
Luz et al., 2014	Quizzes Discussions Active game tasks
Cook and Twidle, 2016	Text-based Consequence based Storytelling Chapter based
Ali et al., 2017	Active game tasks Level based Storytelling
Baranyi et al., 2017	Platform Level based
Cosma et al., 2016	Rule-based Level based
Mortara et al., 2014	Trivia Puzzles Minigames Interactive Exhibitions

TABLE 2.2: Categorisation of the results from the literature review

2.3 Co-Design Workshop

The literature review revealed a lack of research diversity on the subject of informative games to increase knowledge and awareness. As a consequence, the co-design workshop Information Game Co-Design Workshop (IGCW) was created modelled after the Privacy Game Co-Design Workshop (PGCW) by Berger et al. (2017). This workshop aimed to facilitate the inclusion of the target group in the design process and through this collaboration, gain a deeper understanding of their problem.

The method of a co-design workshop was selected to involve female secondary school students in reflecting on their knowledge of programming and technology to generate ideas related to the development of games used to presenting information. The intention behind this was to get instant response to ideas and concepts, generate ideas they would want to use, and make decisions more efficiently (Petersen, 2018). A co-design workshop for an information game is used as a mechanism for involving the intended user in the creative process of exploring ideas, while at the same time it increases the probability of the elements and scenarios selected for the game are relevant and engaging (Chisholm, n.d.).

The workshop consists of a board, a cover board and seven Play Cards. The board is divided into four phases, Reality, Meaning, Play, and Combine, where each phase represent a new task for the participants. The tasks are depicted on the cover board that conceals the interactive phases. The Play Cards are found under the cover of the play phase, and the participants can choose the card they find most interesting.

The workshop also provided insight into what girls wanted to know more about in regards to technology and programming as it asked them to reflect on the type of information they want in the game. It was interesting to see that the questions they noted down on the board were quite general and open. Examples of the questions are seen below.

- What is IT?
- What can programming be used for?
- What is the difference between something technological and something that is not?

This shows us that girls in secondary school have a limited understanding of what IT is and how it can be used. It became evident during this first phase of the workshop that none of the participants had a previous comprehension of what programming and technology really entailed. Consequently, the groups struggled to formulate questions as a result of their missing understanding. In addition to the few questions listed above, both groups noted that they knew little about programming, only that it was associated with coding. The practical use of it was however, unfamiliar.

The purpose of the workshop was to include the target group in the idea-generating process of creating a game to raise awareness of IT. The main themes from their final ideas were (1) actions lead to consequences and (2) an entertaining storyline. Both techniques are commonly found in many serious games, which suggest that they have promising value. A common pattern in both groups' ideas were the focus on practical learning, especially by solving programming tasks. Although the intention of the game is not to teach programming, as there exists a range of serious games with that purpose, the idea of using practical tasks to gain new knowledge seems appealing to girls.

None of the groups discussed ideas organised around more traditional educational elements, such as presenting informational text, videos or using

quizzes. The participants may have seen this as too conventional or outmoded, but it might also stem from the fact that very few games utilise information presenting as its main type on conveyance method. This could mean that the participants would not have a mental image or previous experiences to draw from. By introducing it in an engaging and fun manner, such as in a game, the effects might increase compared to standardised teaching methods.

Chapter 3

State of the Art

Serious games are gaining more and more attention as its educational values combined with entertaining aspects have demonstrated positive effects on both learning and motivation (Wouters et al., 2013). It represents an alternative method of presenting and communicating new knowledge that is in line with modern theories on effective learning through active, situated and problem-based tasks (Kiili et al., 2014).

The goal of this review on related work is to analyse previous efforts on serious games to gain insight into the approach and methods of creating an effective information game. It aims at answering the research questions RQ1.1 and RQ1.2. The chapter will try to classifying engagement elements and learning elements that are commonly used in serious games, in addition to investigating serious games specifically designed for females. The end goal will focus on identifying game elements that females find interesting and that are efficient when used in informative serious games for raising awareness.

Section 3.1 inquires into the motivational aspect of serious game, whereas section 3.2 and 3.3 explores game elements for raising awareness and engagement elements respectively. Section 3.4 looks at the relationship between games and girls.

3.1 Motivation in Serious Games

Serious games devise an environment where the player can experience involvement, engagement, motivation, and flow (Pange, Lekka, and Katsigianni, 2018). Motivation is an especially necessary requirement that affects the result and impact the game has on the player. It is therefore, essential to

design an appropriate motivational game that does not rely on ad-hoc motivation to arise unpredictably. A well-designed serious game with thought out motivational elements has a better learning outcome than non-digital game based applications (Costabile et al., 2003; Clark, Tanner-Smith, and Killingsworth, 2015). Additionally, research has shown that gender is a noteworthy factor as female and male players have dissimilar views on games (Paliokas, Kekkeris, and Georgiadou, 2008; Stege, Lankveld, and Spronck, 2011).

Psychological research suggests that there are several ways of experiencing motivation, where two include intrinsic and extrinsic motivation (Cherry, 2018). The first one arises from the inside and is typically related to the individual's own desire to perform an activity. This is usually done for personal rewards or own winnings. Extrinsic motivation, on the other hand, is the result of outside stimuli, either to get something in return or avoid punishment.

Intrinsic and extrinsic are important motivational aspects to consider when designing a game as they can influence how the player perceives or feels in regards to the game. Some researchers have stated that extrinsic motivation takes away the excitement of playing the game, resulting in the player not wanting to play when all the rewards are collected (Vriend, 2017). The devaluation of a task might lead to the belief that without a reward, the motivation for doing the task cease to exist, suggesting that without incentives, the player no longer have the desire to learn. This is not the intended outcome of serious games. However, rewards and time limits are factors that make games interesting and exciting. They make the player strive to achieve better results and drive user engagement (Shodhan, 2017). It is, therefore, the game designer's task to create incentives that cause intrinsic motivation .

A balanced combination of intrinsic and extrinsic motivation effectuates "flow", the experience of being completely submerged in an activity, leaving everything else less important. The concept was first introduced by Csikszentmihalyi in 1975 and describes the fundamental balance that should exist between the arisen challenge and the player's ability to solve it (Csikszentmihalyi, 1975). Figure 3.1 demonstrates the principle by illustrating the flow zone in the middle of a biaxial graph where challenge and ability are values along the axis. If a game is too demanding, it will lead to the feeling of anxiety, while if it is too easy compared to the player's abilities, it will becomes boring. Flow is essential as it provisions the player with motivation and helps

keep their attention for a longer time (Chen, 2007).

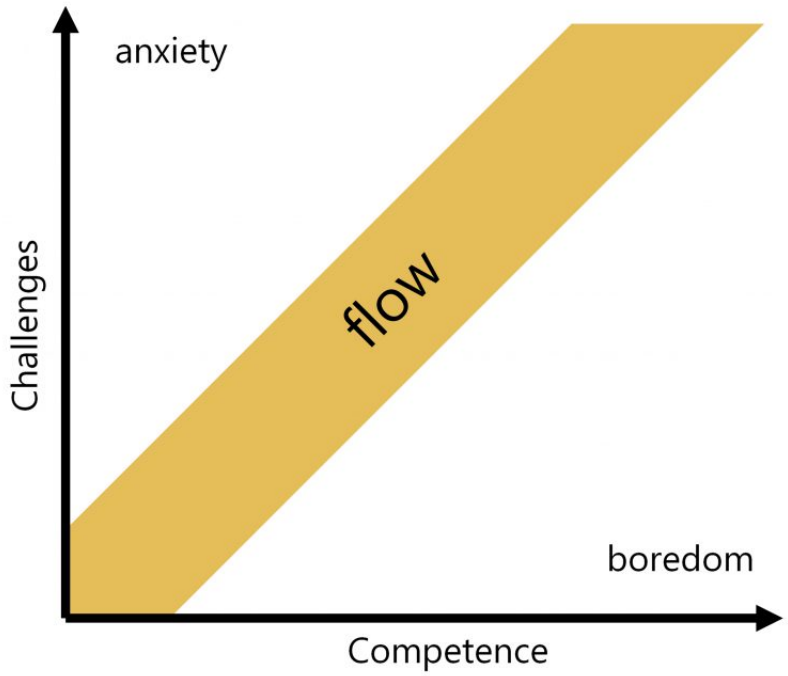


FIGURE 3.1: The idea of flow relates to the balance between the player's skill level and the game's difficulty (Berg, 2016)

3.2 Raising Awareness through Serious Games

Modern technology has the potential to raise awareness in an alternative and engaging way. Previous research has demonstrated that serious games with the aim of increasing the player's awareness have received good results Girard, Ecalle, and Magnan, 2013. This suggests that they can be used to capture the public and change peoples outlook on societal issues. However, it is important to consider the pedagogical principles and the correctness of the information communicated to ensure the desired outcome and impact on the player.

The research done prior to this thesis revealed a gap in the existing literature on awareness raising games with focus on presenting information. Few games have been described or analysed that have had the intent of providing information as the main game feature. Nonetheless, the findings unveiled several other interesting elements from awareness raising games that

are transferable to serious games aimed at presenting information. This is discussed in more depth in section 2.2.2

3.2.1 Awareness Raising

Awareness raising is seen as a constructive and possibly catalytic driver aimed at challenging the opinions, actions, and behaviours of others in a positive manner (EIGE, 2013). The primary method for raising awareness is to present information or educate the public about certain issues or topics, trying to influence them to achieve the desired change. It is a vague and general term that nevertheless is recognised in most communities and cultures and strives to promote visibility and understanding within a society (Sayers, 2006).

Games are an excellent way of generating awareness for a societal topic, as it enables interaction and utilises exciting and activating elements that can be enjoyable to many (Jans et al., 2017).

Game Elements for Raising Awareness and Educate

An assumption related to the use of informative serious games to increase awareness is that they are not only likely to engage the player, but also to facilitate change in behaviour and perception. This belief is based on previous research conducted in the specialisation project but also the observation of how the populace uses and depends on technology today. This is especially relevant when looking at the target group.

Serious games are thought to engage the learner in a learning or awareness raising situation by the means of multimodal, often narrative oriented methods that they can immerse themselves in, resulting in learning outcome (Csikszentmihalyi, 1990). Ravyse et al. (2016) suggest that it is this use of narrative storytelling linked with learning material, that provides a successful outcome of a serious game. In contrast, a game where the narrative is unrelated to the material it presents, the learning may be undermined or degraded. This is also represented in D'Apice et al.'s (2015) explanation of essential resources when creating educational games:

1. The story to narrate
2. The world the protagonist explores

3. The puzzles the player has to solve
4. Which learning content to convey and the most effective way to convey them
5. Strategies to assess the player/student performance

The last two were added by D'Apice to provide the educational aspect. D'Apice et al. describe the story as a method of involving the player and to accommodate them in relating to the problem in the real world. This is done by stimulating real scenarios and places to demonstrate situations where the learning outcome can later be applied.

In addition to narratives, there are multiple other game mechanisms that contribute to raising the player's awareness. Previous research revealed that quizzes, puzzles, and active game mechanics are common elements used to excite the user of awareness raising games. Active game mechanics in this context relates to controlling or steering the character, collecting items, or solving tasks. Other features that enhance the outcome of the playing are providing information, have reward systems, and gain immediate feedback to endorse good behaviour or actions or to explain or review what just happened in order for the player to reflect on the event (Ravyse et al., 2016).

Learning Elements	Comments
Providing Information	
Puzzles	
Storyline	
Quiz	
Immediate Feedback	
Reward System	
Active Gameplay	This would Include: Controlling the Character Collecting Items Solving Tasks

TABLE 3.1: Learning and awareness raising game elements found as part of the review

3.3 Engagement in Serious Games

3.3.1 Common Game Elements

In the paper "Using game mechanics and game elements in learning games", Steven Boller (2014) describes the list of the most common game elements that keep players engaged. It is imperative to consider how each element supports the learning process in the game, as some might become distracting or disruptive to the player. The elements listed in the paper is Conflict, Cooperation and Competition, Strategy and Chance, Aesthetics, Theme, Story, Resources, Rewards, Levels, and Scoring.

Conflict
He notes that for a game to be interesting, there should exist a conflict to stimulate the player's motivation. Although conflicts can take on many forms, it represents an obstacle the player has to overcome. This could be to battle the enemy, solve puzzles, or get to were they need to be.

Cooperation and Competition
Cooperation is often thought of to be the better learning element in educational games, as competition can be de-motivating and have a negative impact on the player. This can be seen in situations where some players become too focused on winning or dominate over other players, creating an unhealthy environment for those who fall behind. Although competition can be appropriate in some circumstances, cooperation can foster teamwork and motivate players to solve tasks together.

Strategy and Chance
Including strategy in a game provides the players with the opportunity to explore the outcome and consequences of their own actions. They become in control of the game's end result. In games related to chance, on the other hand, the player becomes more reactive as they have less power over the outcome.

Aesthetics
Aesthetics have the ability to draw people into the game and can be an effective tool to engage the player. It facilitates the immersion of the player into the game. Pleasing aesthetics in serious games can elevate the experience, as the informative, learning content might be considered dry.

Theme
Theme is also an element that can help increase the player's engagement and interest in the game. Although a theme can be a nice touch, it is important to ask whether or not it is necessary and if it will enhance the gameplay.

Story
As mentioned in previous sections, the use of a story is common in many serious games, as it works to connect all parts of the game and make it relatable and meaningful. It is also easier to remember information if it is presented through a narrative than to read it without a context.

Resources
Resources are game mechanics that are accessible to aid the player on their quest. This can often be money, equipment, or materials for building. In The Sims, money can be considered a resource alongside materials for building and decorating a house.

Time
Time can be used as a diverse game element, ranging from a constraint where the player has to solve a puzzle before the time runs out, or it can be a resource or a method of compressing real-world events in a more manageable amount. This is especially present in games for life simulations, where one month in the real world is one hour in the game world.

Rewards and Scoring
These game elements are central in many games and work to engage the player. Rewards or points can be earned by solving tasks, collecting coins, or accomplishing obstacles. It is linked with the popular mechanism of gamification, where the participant receives achievements for doing duties or reaching milestones. However, some are of the opinion that too much reinforcement can have unwanted effects, and may be damaging to learning (Vriend, 2017). For instance, a player should be rewarded only for completing tedious tasks, not interesting ones, as these are a reward in themselves. Rewards should also be given for performance and not completion.

Levels
Levels are a means to ensure a gradual increase in difficulty that allows the player to become acquainted with the game and master the needed skill set. It generates motivation resulting in the player wanting to continue playing to achieve new triumphs. Nevertheless, if the game becomes too difficult too

fast, the player might become overwhelmed and discouraged, resulting in them losing focus of the learning elements.

Boller explicates that the game designer should select the elements that are relevant to the game's purpose and learning goals. The elements and mechanics are cooperative components aimed at establishing a meaningful experience for the player.

3.4 Serious Games Designed for Girls

The earlier work on computer culture and gender explored the narrow view on gender stereotypes. Their focus was on comprehending why gaming had become gendered and why girls were not partaking the same way as boys (Dickey, 2006). It proposed theories on why males were more prominent in digital gameplay than women, looking especially at the portrayal of females in games (Alserri, Zin, and Wook, 2017). They found that women were often depicted as victims in need of saving (Gailey, 1993; Bryce and Rutter, 2002; Dickey, 2006) or overly sexual compared to their male counterparts.

The Gamer Label

This traditional view on game players has recently experienced a transformation where the digital game industry looks to become more involved in understanding the image of the gamer (Dele-Ajayi et al., 2018; Chess, Evans, and Baines, 2016). Parallel to the revolution of the game industry that has evolved to include various new devices, different genres, and an increased number of games, there has been a rise in the number of female gamers. Statistics are now reporting approximately equal numbers in male and female gamers (ESA, 2018), but contradictory, gaming is still associated with men (Paaßen, Morgenroth, and Stratemeyer, 2016; Fox and Tang, 2016; Gee, 2007). The missing understanding of who the actual gamer is can evolve to marginalise those not fitting the typical gamer label (Barr, 2017). A report from Marcotte (2015) unveiled that girls are unlikely to play games that unveil their identity, for instance, games dependent on voice-over. This is substantiated by Chess et al. (2016) that found that non-typical gamers feel the need to hide their identity when playing.

The Continuation of Stereotypes in the Gaming Culture

As seen in earlier research on gender and game culture, stereotypical perspectives continue to cast a shadow over digital games today. Digital games

are still first and foremost designed by males for a male audience despite the growing number of female players (Dele-Ajayi et al., 2018). In earlier studies, as an effort to lessen the gender gap, games were created with females' interests in mind. The emerge of games targeted toward females probably contributed to the increase of female gamers. However, the majority of the first female games focused on fashion and accessorising, relying on feminine stereotypes (Dickey, 2006). Cassell and Jenkins (1998) advocated care when using female stereotypical interests as the base of one's game as this could trivialise the female culture and lead to marginalisation.

The Gender Gap in Games

Several studies have tried to acquire an understanding of the existing gap between female and male players. Some point to the way females have been portrayed in games, often as victims in need of saving by a male hero (Gailey, 1993; Bryce and Rutter, 2002) or an object of violence. The stereotypical image of female game characters may hold off women from playing as they feel their identities being marginalised and disregarded.

Violence in realistic environments has become a popular part of many games targeted at teenagers and adults (McGloin, Farrar, and Fishlock, 2015). A study by Hartmann et al. (2014) suggests that one explanation for the low attendance of female gamers are their lack of interest in violent games. Women show little interest in games containing brutal themes but are, on the other hand, more drawn to games with social aspects and meaningful interaction.

Female Game Design

An organisation of design elements engaging to females have been studied in an attempt to surpass the stereotypical characteristics and outlook on female gamers (see table 3.2). In a study by Kafai (1998), it became clear that girls favoured realistic game environments with little violence or negative feedback for taking wrong decisions. Similar studies revealed the value of having meaningful content presented through dialogue and character interaction (Rubin et al., 1997, Castell and Bryson, 1998). Having a game with a cooperative nature was also preferable in contrast to a competitive environment revolving around an action-oriented setting where the player ignored one another (Romrell, 2013; Barr, 2017).

The role of the game's narrative was found to be central to females' enjoyment of games. This gave them the opportunity to explore and engage with characters facilitating social interaction (Castell and Bryson, 1998). However, the female role in many storylines is often presented as underdeveloped and

dependent on male characters (Suellentrop, 2018). This, in contrast to the complex male persona exhibiting strength and independence (Dickey, 2006). Kowert, Breuer, and Quandt (2017) states that these male-centric narratives might furnish the proliferation that video games are a boy thing. The promotion of stereotypes in games creates a barrier for females not finding games to identify with or wanting to play.

Engaging Game Elements	**Less Engaging Game Elements**
Rich narrative	Violence
Meaningful dialogue	Too much competition
Cooperation and social interaction	Degrading representation of women
Appropriate level of challenges	
Engaging characters	
Customisability	
Strategy and skill (beyond shooting games)	
Exploration	
Vicarious adventures	
Sophisticated graphical and sound design	

TABLE 3.2: An overview of game elements that appeal to females (Dickey, 2006)

3.5 Discussion

The literature presented in this chapter revealed that there are several aspects to take into account when designing a serious game. In the case of this research focusing on exploring the use of informative serious games to raise awareness about IT, it is essential to investigate how to present information excitingly and engagingly. There needs to be a balance between the educational aspects of raising the player's awareness and the entertaining and motivational elements that encourages the player along.

Section 3.3 elaborates on the engagement mechanics that were identified to maintain the player's motivation. Boller described Conflict, Cooperation and Competition, Strategy and Chance, Aesthetics, Theme, Story, Resources, Rewards, Levels, and Scoring as the fundamental game elements for supporting the player's learning process (Boller, 2014). Set against the detected awareness and learning objectives, it becomes possible to determine the most suitable elements for informative serious games.

It is however necessary to examine the findings from section 3.4 before defining the collection of game elements. From studying the literature, it becomes clear that there is a gender gap in the game culture, where male and female gamers have different views on serious games and games in general. Although they find many of the same mechanisms enjoyable, girls are less susceptive to games containing violence and negative representation of female characters. The set would have to be founded on mechanisms that both genders find agreeable, thus ensuring a game's ability to capture and accommodate a broader variety of users. By studying table 3.2 and comparing it to the results from section 3.2 and 3.3, we identify the set of game elements to be desirable when designing an informative serious game.

When studying the literature on serious games, there exists a vast archive to contemplate and many previous attempts to learn from. Table 3.3 provides the awareness raising elements that can be used to complement the entertaining mechanisms that facilitate a meaningful game session. The construction of an engaging, informative learning environment ensures that the player does not passively receive information but that new knowledge is obtained through active tasks.

Learning Elements	**Engaging Game Elements**
Provide information	Rich narrative
Quiz	Reward
Consequential play	Meaningful dialog
Repetition	Engaging characters
Emotions	Consequential play
Points	Appropriate level of challenge
Real scenarios	Cooperative
Sophisticated graphics and sound design	Vicarious adventure

TABLE 3.3: A mapping of learning and engaging game elements with specific focus on designing games for girls

Chapter 4

Game Concept and Evaluation

This chapter describes the first evaluation of the intended game concept for the informative serious game to be developed. It provides a presentation of the initial game idea, its target audience, the storyline, and learning goals and game elements used. Additionally, a description of a group discussion concerning the first concept is given. The game's design decisions were made as a result of the co-design workshop that was run during the specialisation project, and the results acquired from the related work in Chapter 3. These decisions will help answer the research questions RQ1.1 and RQ1.2.

4.1 Game Description

In this section, a description of the target group, the storyline, and the goals of the game are presented. CITY is intended as an online game designed to explore the potential and promise of using informative serious games to raise awareness of IT. It is created with the intention of giving the user a brief window into the world of technology and its significance.

4.1.1 Target Audience

The game is targeted toward teenagers in secondary school with the aim of increasing their awareness of IT. Chapter 2 elaborates on how young females have a missing understanding of what technology is, how it is created, and the value it holds. They are not aware of the impact technology can have on the world or how it is used to help others. This was further analysed in interviews with secondary school girls during the specialisation project, revealing

that even though they have limited previous associations to the subject, many are eager to learn more. However, few have had the opportunity to do so.

The game is intended as a measure to make information about IT available to a broader audience. It does not require the participants to travel to an institution to learn about what IT entails, neither does it demand people to come to schools to lecture about it. This makes it an accessible digital medium. The story and the information is presented in Norwegian to ensure that it is comprehensible and accessible to all. It can be combined with the elective programming course in lower secondary school and be used to give the students a brief window into the world of IT. This would give them the necessary information they would need to make an educated decision on whether or not to take the course.

4.1.2 Storyline

The limited awareness among girls, is considered by literature to be one of the most central sources for the under-representation of female interest in IT. The presentation of correct and engaging information is therefore an imperative part of the development of this serious game. The method of stories and narratives are suggested by researchers to be an effective method for representing information in an intriguing and entertaining manner.

Game stories can be weaved into the game and clarify the purpose of why the user is meant to play it. It is also an instrument to drive the user forward and motivate them to continue playing. It can take advantage of the player's need to know how the story ends. Researchers have also demonstrated that stories and fantasy elements can help the player remember better. Additionally, it enables the use of real-life scenarios the user can connect with and exploit previous association to.

The complexity of the story increases with the complexity of the skill that is to be thought through the game. For higher levels of skills, the game's story might need to rely more on simulated realism than for games teaching basic knowledge that would require a simpler story. These simplistic stories are meant as elements of fun and entertainment and are incorporated with the purpose of not distracting the player from the actual learning. They do however, provide a feeling of curiosity and novelty that encourages the user forward through the game.

The results from the co-design workshop where the target group explored game ideas and genres they found most interesting, revealed their interest for stories. They enjoyed games where the player is depicted as a hero tasked with saving the world or solving an unsolvable problem. Another group looked at how the player could be in charge of deciding the outcome of the game and how their actions would have consequences. They also liked the idea of solving problems to advance in the game. With these ideas and opinions in mind, the concept for the game was formed.

The story of the game is set in the city of "CITY", a peaceful town with a lot of technological resources. However, the mayor has decided to ban all technology on the basis that it steals jobs from hard-working people, huge corporations misuse the citizens' personal data, and that people are more occupied with checking their phones than talking to others. He wants to create an including and caring society where people interact with each other the way they used to before technology changed everything. Although the intentions of the mayor seem good, ignorance concerning technology can be dangerous.

The aim of the game is to gain enough information to convince the mayor that banning technology is not the right decision. Although his claims have some truth to it, understanding the underlying causes is imperative in any situation. The player moves forward in the game by travelling from place to place to learn about IT. Inside each location she can talk to employees and visitors, and play minigames, to gain insight into what technology is and how it affects us. At the end of the game, the player will use her new-found knowledge in a debate against the mayor. The final game is described in detail in Appendix A.

4.1.3 Learning Goal

The purpose of this game is to raise girls' awareness of IT and the people working within the field in an understandable and accessible manner. IT is an umbrella term that makes it almost impossible to include all aspects of it or specific areas. A few have therefore been selected based on girls' interests and the likelihood of them finding the chosen scenarios engaging and attractive.

In table 4.1, the learning goals for the game are listed. In addition to having the main focus of presenting information about what technology is, the game wants to demonstrate how technology arises and who is behind its creation. An important part will be to emphasise women's position in the technology industry and other industries where IT is used. The intention behind this is to challenge the existing stereotypes many girls have about people working with technology and especially programming. Showing them that there are females working within these types of fields seeks to establish role models that can inspire them to increase their interest and curiosity of IT.

Primary Learning Goal	**Secondary Learning Goal**
Know what technology is	Know of the benefits of having and using technology
Know what technology can be used for	Know of the various areas where technology is used
Understand how technology is created	Understand that there are many paths that lead to a career in technology
Gain insight into the people working with technology	Become aware of the existing stereotypes
Learn about women working with technology	Make women in technology more visible

TABLE 4.1: Primary and secondary learning goals

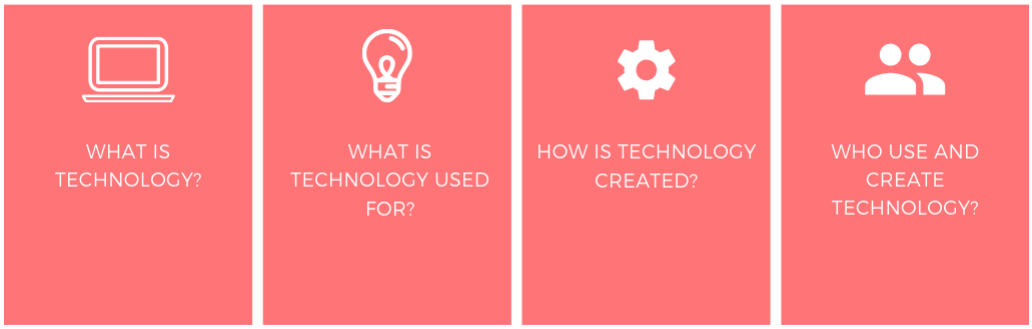


FIGURE 4.1: The building blocks for the information presented in the game

Figure 4.1 depicts the four pillars of information areas that are to be presented to the player. They are connected and dependent on each other, where the succeeding blocks rely on the player's understanding of the first block to gain a deeper perception of the others. Without knowing what technology is, it becomes hard to grasp the value it has and the impact it makes.

4.2 Concept Evaluation with NTNU Students

A group interview was conducted with student participants from NTNU with the intention of raising new insight and new perspectives on the concept. The goal of the interview was to hear their thoughts on the game's story, the game design, and to gain new inspiration and improve game elements. The list of questions can be found in Appendix C.

The benefits of conducting a group interview include having the participants generate additional and more varied responses, as the ideas of one participant might expand the ideas of another and stimulate the group to bring about new ideas. Such interviews facilitate a formal or informal environment that allows individuals to brainstorm ideas and utter their opinion on the topic at hand (Fontana and Frey, 1994). Normally, a group interview has between four to eight people as the risk of some participants becoming overrun by more dominating members increases with the number of people in the group. This session was held with 6 participants and consisted of a mixture of both male and female. They provided interesting and constructive feedback and were eager to partake in the discussion.

A disadvantage of holding a group interview is the possibility that some might find it unnerving to express their thoughts in front of others. Additionally, the group might only convey the opinions that are accepted within the group. A challenge that did arise during the interview was that some members exhibited dominating tendencies and had so many ideas that other members were kept out of the conversation. This was regulated by asking the modest participants first and continuously throughout the discussion, making sure their voices were heard. The seating arrangement was made into a circle to ensure the visibility of all members, thus establishing an including environment for the participants to carry out their discussion.

4.2.1 Results

The questions asked during the sessions relied on the paper prototype shown in part in figure 4.2 and were related to the game concept and game elements. They were asked what they thought of the story, and everyone seemed to like the idea of the evil, ignorant mayor that the player needed to beat. It was noted that "*As long as it doesn't become too cliché.*" When discussing the locations and scenarios the player would visit, the participants stated that they

thought it was a clever way to get the player more involved and interested in the technology being used. *"If for instance, they have a family member that works in that sector in real life they'll probably think it's cool to learn more about it, which will make them more motivated to play the game."* They emphasised that the scenarios needed to be as applicable and engaging as possible to underline its relevance to the player.

FIGURE 4.2: Excerpt from the initial paper prototype shown to the participants

On the storyboard that was shown to them, the player visits a hospital and an IT business. They found these locations to be a very good start and suggested additional places such as a section related to the environment, a school, a police station, online shopping, and even a blogger. An additional proposal they had was to rename the IT business to something more recognisable such as Google, Facebook, or Apple.

An important element in all games is the methods used to engage the player. The findings from the examination of related work in Chapter 3 revealed a set of appropriate learning and engagement elements that was used as a foundation for the development of this concept. The participants were invited to look into and comment on the conceptual idea that had been presented to them and encouraged to explore creative and alternative methods. One suggested that the minigames could be inspired by Mario Party minigames, an interactive board game filled with different minigames. On the other hand,

others mentioned that the whole concept of minigames would be time and resource consuming and an assessment needed to be made on whether or not they should be a part of the game at this moment.

Another participant proposed to use quests and solving problems to a greater extent than initially intended. This could be done by having the player help characters get items from other locations or answer their questions. An example was given of a patient that needs a pacemaker, and the player would have to go out and find that item somewhere. Another interesting idea was the proposition of having incidents related to the banning of technology. For instance, experiencing the loss of WiFi or cell reception, and seeing the sky become darker and darker.

After hearing about the idea of making smaller quests a central part of the game, another participant suggested to make the walking a more essential part of the gameplay as well. By adding interesting elements along the way, the player's motivation would increase compared to just pressing the arrows on the keyboard and moving to the next location. One thought was to use fun facts about technology, preferably humorous, or talking to people on the street, clicking on buildings and items to see either something funny happen or to have some interesting information that would help the player become more aware of technology.

They were asked to think about the game mechanism of collecting objects and receiving points, which were both ideas they seemed to like. It was noted that these elements were great for motivating the player and one replied that "*It's also important to have flashing lights and sound effects when the items are collected*." To avoid the element of boredom it was said that if the game were to have a quiz at the end where the player battles the mayor in knowledge, it is important that it does not require the player to remember every little detail but rather the bigger picture.

Other interesting thoughts that were mentioned were to consider using isometric design instead of two-dimensional. The reason was that if the game allows the player to explore on her own, this would make it easier to have an overview of all the possible locations. Furthermore, having some locations locked could increase the engagement of the player and the desire to continue playing, as it would require them to solve a puzzle or a task to gain access. They were also very positive to using video, images and animations in the game, as they thought text could become tiring in the long run.

4.3 Changes as a Result of the Concept Evaluation

To have a structured overview of the suggestions made during the group interview, all ideas were organised into a changelog. These proposed changes were then evaluated to see if they would serve a purpose in the game and if there would be enough resources to implement them. Based on this, it was decided to incorporate the suggestions presented in table 4.2. These will be implemented in the prototype that is to be created in the next iteration phase of the development of CITY.

ID	Scenario	Description
1	All	Use video, images, conversations, voice-over
2	Location Scenes and Battle	Use relevant and real places/scenarios the player can feel a relation to
3	Location Scenes and Battle	Consequential play: let the user become more aware of their own actions and the consequences they can have
4	All	Have a continuous story. Make the walking an essential part of the game not just a method of getting from A to B
5	All	Collect objects that give you points that could be used against the mayor
6	Street Scenes	Incidents related to the banning of technology that gradually increases in impact • Shut down the Internet • Lose cell reception
7	Street Scenes	Unexpected side events • Finding items on the street with relevant information or just fun elements
8	Street Scenes	Solve a puzzle to gain access to a new location

TABLE 4.2: Changes made to the game after the concept evaluation

Chapter 5

First Prototype and Evaluation

This chapter describes the evaluation conducted after the first concept prototype assessment of the concept. In this iteration, the game has evolved into a wireframe aimed at conveying the idea behind the informative serious game CITY to a greater extent than before. A representation of what was shown to the participants is found in figure 5.2. The game concept, the story, and the planned game mechanics are assessed by experts with a background in game development and pedagogy, as well as a member from the target group. The chapter will further present this iteration's version of the game, the purpose of the test, the participants, the process, results, and finally a discussion.

5.1 The State of CITY

Figure 5.1a and 5.1b provides a visual representation of the evolution of the game CITY from a paper prototype to a digital wireframe. After the paper prototype had been evaluated by the participants in the previous iteration, changes and further development were made to the game. Table 4.2 provides a systematic list of the changes that were implemented based on the feedback by the group.

The previous version of the game had focused on establishing the story and the concept. With the incorporated suggestions from the students, the game now exhibits a wider, more varied collection of game mechanics to enhance the player's engagement. The wireframe also contains a proposal of the information to be presented in the game, as well as topics of conversations the user will interact with, and specific characters.

(A) Representation of the hospital scenario as seen in the first prototype

(B) Representation of the hospital scenario as seen in this iteration

FIGURE 5.1: Visualisation of the hospital scenario from two separate iterations

5.2 Expert Evaluation

Expert evaluation is the technique where user experience specialists evaluate the UX of a specific system (*Methods for expert evaluation*). It facilitates an environment where the expert can contribute with new insight and point out common and basic problems that can be avoided in later stages of the development.

There are several advantages of utilising this form of evaluation. Firstly, it provides quick and inexpensive feedback of the system, and secondly, it is a method of acquiring response early in the process, making it easier to pivot or make changes if necessary (Hall, 2017). By using experts within relevant fields, they can spot potential problems in the system and recommend improvements based on their previous experience. However, to optimise the result of expert evaluations, one would need to use several specialists and combine their views in a meaningful and constructive manner. Furthermore, as the evaluation might uncover major issues with the system design, the result might be too challenging and time-consuming to handle (Usability.gov, 2013).

The method of heuristic evaluation was also considered for this assessment. It relies on the expert's application of usability guidelines to review the system. Although it is a common method in many formal settings, it is argued that the technique has a lack of flexibility and fails to meet the needs of the developer (*What is an expert review*, 2015). The method is composed of going through a list of heuristics and checking off the ones present in the interface. Although it is considered straightforward both to understand and conduct,

the process does not provide room for the system's context of use or its goal. These are aspects highly valued in the literature of game development. This resulted in the selection of expert evaluation as the method of choice over the heuristic, which was seen as too limiting.

5.3 Interview

Four expert evaluation interviews were conducted to acquire feedback and insight into the early stages of the game. The interviews were based on questions that targeted a wireframe prototype that was presented to the participants. The wireframe had the intended functionality and information of the game, and the interviews sought to evaluate its content.

5.3.1 Purpose

The motivation behind the interviews was to obtain quality feedback from people with expertise and insight into the game topic. The interviewees were from different backgrounds to accommodate various viewpoints, thus taking advantage of their diverse understanding of the topic.

5.3.2 Participants

The interviewees comprised of two game experts, one pedagogy expert, and one expert from the target group. They were selected on the basis of their field of expertise to contribute with insight into the problem area.

All participants were required to sign consent forms before the interviews. These forms informed them about the project, their rights, and their anonymity. The consent form is found in Appendix B.

5.3.3 Process

The interviews in the context of the expert evaluation were organised as semi-structured based on this method's open nature. The object of the interviews was to gain feedback and response from the participants and utilise

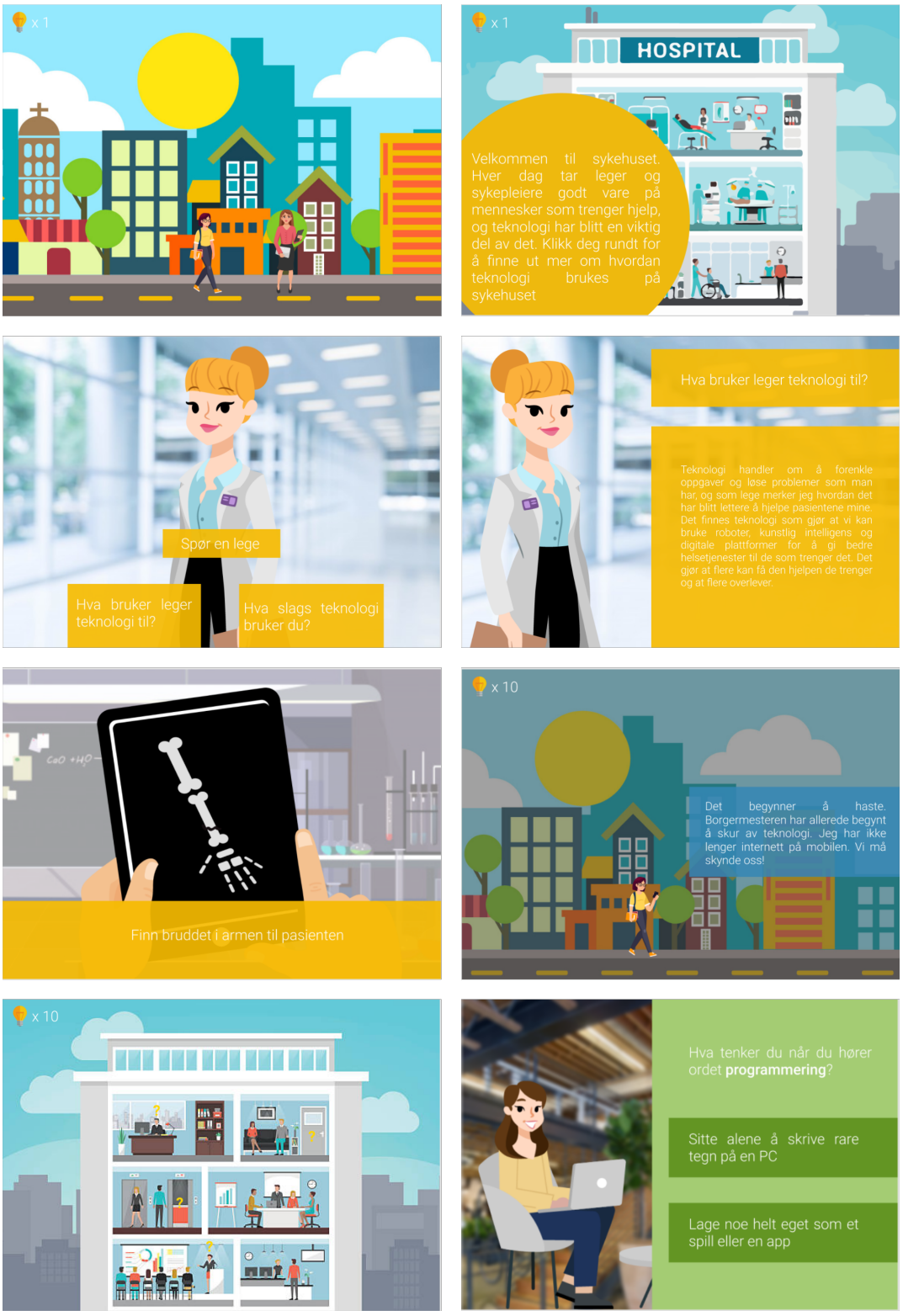


FIGURE 5.2: Sample of the illustrations shown to the interviewees

their expertise to see new approaches and learn from their previous experience. A semi-structured interview is suitable for this as it allows the interviewer to follow an organised interview guide while at the same time,

Participants	**ID**	**Roles**
Pedagogy Expert	Exp 1	Share their knowledge of learning and how to utilise pedagogical methods efficiently in the game. Provide comments on the information provided in the game and how to improve it.
Game Experts	Exp 2 Exp 3	Share their knowledge of game development. Provide feedback on game elements and on how to motivate and engage the player. Elaborate on how to utilise information in games.
Expert from the Target Group	Exp 4	Share their knowledge about games and what they look for in an engaging and fun serious game.

TABLE 5.1: Overview of participants, their identification, and their role in the expert evaluation

explore side tracks that might arise during the exchange. In comparison to a structured interview that follows a fixed set of questions that the interviewer is not allowed to turn from, the semi-structured version permits the interviewer to explore intriguing thoughts the interviewee might have (Cohen and Crabtree, 2006). This was one of the main reasons for selecting this type of interview method, as it enables the interviewer and interviewee the opportunity to elaborate on topics in further detail without forgetting relevant questions.

In preparation for the interview, the matter in question was prepared and the interview guide was finalised. These can be found in Appendix D. In addition, background information on the participants and their area of expertise was gathered to be able to highlight relevant issues and take advantage of their previous experience.

The contents of the interviews were captured by writing handwritten notes. It is not enough to rely on memory alone as they tend to be undependable and susceptive to bias. Instead, it is necessary to draw on tools such as audio recording and written notes. To preserve the interviewees' privacy and consider the fact that some become nervous when recorded, it was determined that handwritten notes where to be used. Although audio tapes supply the interviewer with a full record of the conversation, it is laborious and time-consuming to transcribe and inadequate in apprehending body language or the context of the interview (Oates, 2006).

5.4 Results

This section presents the results from the expert evaluation. The experts were selected on the basis of their expertise in three different fields, pedagogic, games, and being a member of the target group. The interview guide that was used varied slightly between the groups to accommodate and take advantage of the distinct experts unique skills. The interview with the expert of pedagogic revolved around the information and the educational aspects present in the game to a larger extent than the game experts' interview. In the case of the game experts, this was contrariwise.

The guides were divided into two parts where the first consisted of general questions about the game, its concept, the interviewee's first impression of the game mechanics, and the design. The second section was designed to go deeper into the game and explore its content, facilitating a discussion on the information presented, the scenarios selected, and the use of informative games. The experts will be referred to by an ID such as 'Exp "number"' to ensure their anonymity.

5.4.1 Interview Analysis

The results from the expert evaluation were analysed using thematic analysis. This involves iterating through the data obtained during the interview and mapping it to find the most important themes. The procedure consists of six steps (Mortensen, 2019):

1. Get familiarised with the data
2. Specify preliminary codes to the data to describe the content
3. Look for patterns or themes across the interviews
4. Summaries the themes
5. Define the themes
6. Write down the results

Every interview was read carefully to acquire relevant and intriguing details or statements produced by the participants. Opinions and comments that frequently appeared across the interviews were selected and divided into segments of significance. These sections were defined as themes and were

chosen based on their relevance to the research questions and their characteristic of corresponding to other interviewees' conclusion and statements.

5.4.2 Results from the Interviews

Concept

Interviewee Exp1 expressed enthusiasm related to the concept and commented on the effective use of good versus evil, the young versus the adults. She revealed that she had used the concept of an evil mayor in an activity involving secondary school students, with good results. They seemed to become engaged by the idea of conquering an authority figure such as him. Interviewee Exp2 thought the idea was captivating. "*I like the idea a lot, and the theme it is built on is extremely important. It's critical that we address the problem related to the low number of women in IT. This could make younger people more aware of the issue.*" Exp3 found the narrative intriguing and she like the concept overall, stating that it was comprehensive. "*You have a goal from the start and you continue working towards it throughout the game. The story is constantly connected.*" Exp4 thought the use of consequential play made the player more in control, and at the same time, it made the story more dynamic and interactive.

Games for Presenting Information
When asked about their thoughts on games for presenting information, all of the participants answered that they saw it as a good idea. Some stated that it provided an engaging medium to reach young people as they spend considerable time using computers and mobile devices either on social media or playing games. Exp2 said "*Games are a comfortable medium to them and providing them with information about a relevant topic might become more interesting in that setting.*" Exp3 stated that "*The current generation is much closer linked to games than for instance books. They are used to looking up information on the Internet, making it harder to motivate them to use conventional methods of teaching such as textbooks.*"

Game Elements

When discussing the game elements present in the game, the participants had mixed opinions. A consensus between Exp1, Exp2, and Exp4, was that the game elements were satisfactory and that they would be engaging enough

for the players. Exp1 did however, state that sometimes the tasks were too easy and that it should be made more challenging to maintain their engagement. Exp1 added that considering the desired duration of the game, which should not be too long, the game itself must be solvable in a reasonable amount of time. Exp2 explained that since the narrative was so pertinent, other game elements could be less prominent. She substantiated this by pointing at research on the use of narratives in games, describing its effect on the player. In contrast to the other participants, Exp3 was more sceptical to the current elements aimed at engaging the player. She explained that she thought they lacked an increase of difficulty and that more challenging obstacle should be incorporated. She thought it could be hard for the players to understand the purpose behind the location visits and that an idea could be to include intermediate objectives to clarify this. The interviewees said that the transition between day and night was an interesting and driving mechanism to hurry the player along to the next location and to the mayor's meeting.

The Information

There was a consensus between the participants that the information provided in the game was relevant and suitable for the target group. Exp1 described it as "*easily comprehensible but varied and relevant*." Exp4 said "*The information was appropriate and relatable. Not many understand how dependent we are on technology. That it is used almost everywhere*."

When asked about the possible benefits of receiving this information, Exp1 answered that it will start a thought process in the player. "*These are topics they know of but don't necessarily know much about. It is helpful to build from their fundamental understanding to teach them something new*." She elaborated by saying that many might find technology a bit scary. For instance, they might be fearful of doing something wrong or be concerned with their personal data. Exp2 mentioned for those who are eager to learn more, supplementary information could be added in the game. She exemplified by saying that the additional information could be unlocked when solving a task or reaching a certain point in the game and then be added to a notebook. The added information would not influence the game's outcome but work as a bonus for those wanting to know more.

Presenting the Information

The interviewees were asked about how much information is viable in one scene. Two answered that they thought the current amount seemed fine as long as it did not become more. One added that there should be less text in the first images to make sure that the player does not become bored early on. However, Exp2 and Exp3 both thought two sentences were enough text in one scene.

All the participants were positive about using other means of presenting information than just text. Video was well received, as was audio, images, and animations. Exp2 had previously researched the use of multimedia in games and had found evidence of its positive effect. "*Information presented through videos and other interactive formats made the facts more fun and engaging*." Exp1 stated that "*Kids today have a short attention span making it harder to keep them concentrated on what you are trying to teach. By using various methods for presenting information, you are ensuring that you don't lose their attention.*"

Other Aspects Discussed

Design

The participants enjoyed the design and aesthetics of the game. Exp4 expressed great enthusiasm in regards to it and said it was a very important element to consider because of the selected target group. Teenagers are especially concerned with how things look and feel. A critical comment made by Exp1 affected the aspect of diversity in the game. It was suggested to incorporate a more varied character cast to have a wider range of relatable people to talk to during the game. Exp1 also relayed that the choice of using a two-dimensional world was advantageous, as the player is more confined to the task at hand and on finding the information than exploring every alternative aspect of the game.

Locations

The interviewees were shown the hospital and IT business locations and questioned on their relevance and effectiveness to raising girl's awareness. Exp2 answered that both were very relevant to girls. "*Many girls are interested in health and choosing professions related to caring for others. On the other side, the IT business is pertinent by demonstrating how IT is created and how it can be to work with.*" Exp4 said in her answer that showing multiple institutions was beneficial as it would provide the player with various sides to IT. "*Hospitals aren't*

the first thing that comes to mind when thinking about technology, but it draws on girls' interest of health care and it demonstrates how IT is used in practice. On the other hand, the IT business illustrates how it is to work as someone creating that technology. Both might change the way people see those working with technology."

Target Group

The participants agreed that the game would be appropriate to lower secondary school students. Exp1 stated that it might become too simple for 10th grades, but when considering 8th and 9th graders, the challenges and information provided was highly relevant and fitting. Exp2 was also of the opinion that the game suited this audience but noted that its elements must be selected with them in mind. "*Students at that age are constantly changing, and there is a big difference in what they find enjoyable at the age of 12-13 compared to 15-16.*" Only one of the experts claimed that the game would be appropriate for upper secondary school students in addition to the lower grades. Exp4 explained that IT is already deemed to be monotonous and a game might have a positive effect on their motivation and engagement levels.

Suggestions from the Expert Evaluations

Location Visits

The location visits were considered as a nice way of gaining the acquired information. By meeting various characters and experiencing different aspects of each location, the player is exposed to situated learning. The player's ability to steer some of the conversations were also found to be interesting, as it facilitates reflection in the user. The experts promoted these game elements but suggested the addition of others as well. Exp3 proposed making scenarios that demonstrate how things would be without technology. For instance, having the doctor show the player how an operation would be conducted with no technological support. Exp3 explained how experiencing the loss of something might be more efficient than just seeing it when it is there. It was also suggested to have intermediate goals during each location visit. The player would understand the purpose of the visit and become more engaged in the game.

The Collecting of Light bulbs

Before the interviews started, the concept of light bulbs was not defined absolutely. When first questioned about the idea, most of the participants replied that the game might not even need them. The other game elements were

considered enough, such as the narrative and the collecting of information. However, when prompting them on the intention of using the light bulbs against the mayor, the interviewees became intrigued. All stated that they needed a real function to be a part of the game. Some ideas that were proposed were:

- Use light bulbs to buy arguments during the debate against the mayor
- Poor answers result in loss of light bulb similar to losing a life when hitting an enemy character in other games
- Collect other items than light bulbs that can be put forward as evidence
- Have the light bulbs signalise knowledge acquired in each location, thus if the mayor asks about technology in the hospital and you don't have enough light bulbs from that location, you aren't able to answer the question and lose that round
- The light bulb can be used to buy hints during the debate against the mayor

5.5 Discussion

The expert evaluation provided novel and helpful insight into the understanding of the game. As illustrated in figure 5.2 and in the results presented in the section above, the experts contributed with meaningful and valuable feedback. Although the experts rely on previous experience and in some cases, professional knowledge, their opinions may differ from that of the target group, and must therefore be considered in further iterations. Nevertheless, their varied background and skill set gave a unique perspective of the game design and how to proceed further. The main focus of the evaluation was to receive feedback on the concept, the game elements, and the learning elements.

5.5.1 Difficulty

The perceived difficulty of the game was believed to be low, especially when reviewing the location visits. The game is mainly for presenting information about IT to raise the player's awareness, but without challenging elements to encourage the player onward, the game stops. The concept of flow is a key

Positive feedback from the evaluation	**Changes to be made based on the feedback**
Intriguing concept and game idea	Less text on the screen. Maximum 2-3 sentences in each frame
An interesting story and a well-established narrative	Investigate the use of game mechanics to increase the player's motivation during the location visits
The information was presented on an appropriate level when considering the target group	Decide an appropriate use of the game element "light bulb". It must serve a purpose
Learning objectives correlated well with the narrative and the game elements	The battle between the mayor and the player must be finalised
The design was creative and believed to be appealing to the target group	

TABLE 5.2: Summary of the feedback acquired during the expert evaluation

element in this where the game should be designed to continually increase the level of difficulty as the player progresses. This can be solved by adding engaging game elements that are not too easy, nor too complicated, leaving the player in a state of flow. The experts did not detect scenarios where the player would encounter situations that were deemed too difficult. However, if this was to be the case, then additional hints or easing of the game mechanics could be implemented.

5.5.2 Elements Aimed at Engagement

When analysing the results from the evaluation, it became clear that the experts were divided in their opinion of how engaging the game elements were. They all enjoyed the overall concept and idea of travelling around the city to collect various information that would help the player in the final battle against the mayor. However, some believed that the current game mechanics would not be enough to keep the player engaged throughout the game. This was particularly true for the location visits as discussed in the section 5.5.1. The interviewees suggested several ideas on how to resolve this, one being to implement intermediate goals for each location. This would not only help the player become more invested in the scenarios but also help them see each location's significance more evident.

Collecting objects were considered a solid method of motivating the player during the gameplay. By having to seek out new objects and capturing them, the player has to actively look for them, making the quest more engaging. Based on this, the idea of the light bulbs was taken further. There was a consensus in regards to the light bulbs' need for a purpose, but deciding on that purpose was challenging. An interesting suggestion was to use the light bulbs as extra lives in the debate. If the player selected a weak argument, she would lose a light bulb, and when all are gone, she loses the battle and would have to start over. Another idea is to use them to keep score of both mayor and player during the debate and have the debater with the most light bulbs win.

5.5.3 Learning Objectives and Elements for Raising Awareness

The information presented in the game was perceived as easily understandable and relevant. Nonetheless, as some of the participants had a background in technology from being game developers or researchers on game development, their knowledge of technology is vaster than that of the target group. The game has nevertheless been developed with the target audience cognitive understanding in mind and should be at an appropriate level, as indicated by the interviewees and confirmed by the participant from the target group.

The goal of the evaluation was not to analyse the game's ability to raise awareness, thus no such investigation was facilitated. However, all the participants exhibited great interest in informative serious games and thought the game in question effectively aided the learning objectives. It was stated that the learning objectives correlated with both the narrative and the game elements, utilising the engaging scenarios to capture the player's attention.

Nevertheless, it is difficult to say if the information is engaging enough for the target group, as knowledge is acquired differently by different individuals. Nonetheless, this was an expert evaluation, intended to benefit from the experts' insight and knowledge to examine the current situation of the game and receive relevant feedback.

5.5.4 Changes as a Result of the Expert Evaluation

This section provides an overview of the changes made to the game after the experts' feedback and ideas. Table 5.3 is organised to demonstrate the suggestions that met the satisfactory criteria to become part of the game. The other proposed ideas were seen as interesting but were either deemed to comprehensive and time-consuming to be incorporated or not beneficial to the game concept.

ID	Scenario	Description	Reason
1	Where needed	Less text in each image • Minimum two to three sentences	Too much text would lead to the player becoming bored and not wanting to continue playing the game
2	Location Scenes	Add more engagement elements to the location scenarios	One game expert found the levels to lack a motivational driver. This could result in the player becoming non-interested
3	All levels	Items need to serve a purpose in the game	Light bulbs need to have a purpose otherwise the player will not strive to collect them
4	Battle	Update the battle between the mayor and the player	The battle is now just an example of how it could be. Needs to be finalised
5	Location Scenes	Create a clearer separation between the locations	Will give the player a sense of accomplishment when finalising a level
6	Where needed	Introduce a purpose in each location	The player will want to fulfil that purpose and experience more engagement during a visit
7	All levels	More diverse characters	More players can identify and feel included in the game
8	Battle	Keep the player's and mayor's score during the battle	Scores are motivational to the player and will increase the engagement felt during the battle

TABLE 5.3: The changelog depicting the changes that were implmented after the expert evaluation

Chapter 6

Technical Description

This chapter describes the technical implementation of the informative serious game CITY, providing a rationale for design choices, frameworks used, and the technology adopted. The source code is MIT-licensed and available at `https://github.com/evesax/CITY`.

6.1 System Architecture

The game CITY is created as a web-based game and the technology and the architecture behind it is presented in this section. The game can be found in a web browser on the URL `http://techinthecity.firebaseapp.com`. It is created as an online game to facilitate being used with ease in a classroom setting where students will only need a computer and the URL above to play. Although an app can perhaps be seen as even more accessible, today four out of five Norwegian schools prohibit the use of mobile phones during school hours (Ertesvåg and Leine, 2019). A web-based game was therefore seen as the best solution when considering today's situation.

There is a vast ocean of technologies and frameworks for creating an online game. The framework CITY is built on Phaser3, an HTML game engine for creating two-dimensional games. It has support for both Canvas and WebGL rendering, in addition to being JavaScript-based. One benefit with Phaser is the framework's compatibility with both native desktop, iOS, and Android, meaning a Phaser game can be exported to various formats.

6.1.1 Phaser

The purpose of using a game engine is to have a foundation to support the development of a game. It is a software development environment that usually provides a developer with an engine to render graphics, a physics engine, memory management, and threading (*The Top 10 Video Game Engines* 2019). It allows the developer to reuse components, thus economising the process of creating the game. There exists a wide variety of frameworks and game engines for creating a web-based game, where most rely on JavaScript and HTML5. Phaser was selected as the game engine of choice for this project because of its diverse areas of use, an active community, and good documentation. These are all important aspects to consider when choosing a framework to work with, especially when previous experience is limited.

Other aspects that were considered before selecting Phaser as a framework:

Advantages with Phaser

- Open-source codebase
- Active community
- Continuous development by the creators
- Good documentation and tutorials
- Ranked as one of the top JavaScript Game Engines
- Facilitates development for both mobile and desktop devices
- Easy to learn and use

Challenges with Phaser

- No visual editor
- Difficult to create native mobile apps

(*Phaser Alternatives and Reviews*)

How It Works

A key concept for any front-end framework that is responsive is the life cycle. Phaser primarily uses three life cycle methods: Preload, Create, and Update (*Phaser - HTML5 Game Framework*; *Phaser*). These are present in every Scene that is created and is used to facilitate interaction in the game. A Scene is

whenever the screen goes dark for a second in order to render a new scenario. When Preload is used in a Scene it makes the added assets available to use later. Create initialises these assets and make them appear in the game, while Update contains the logic that will change in response to an input.

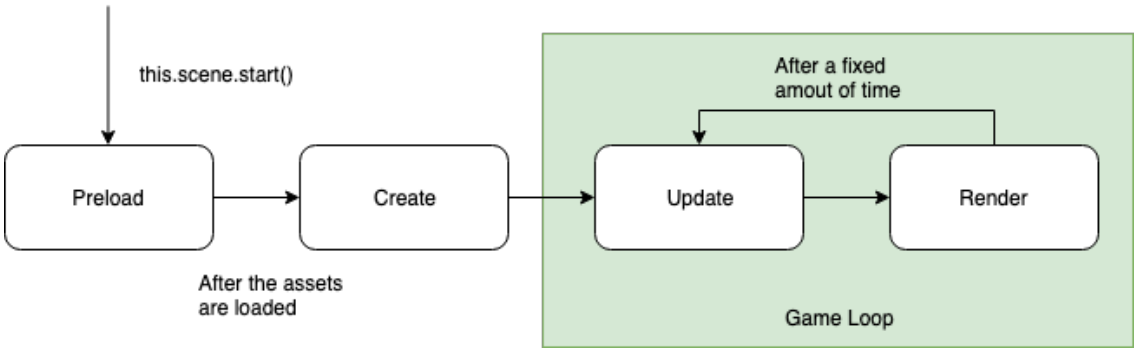


FIGURE 6.1: Diagram of the Phaser life cycle

6.1.2 Alternative Game Frameworks

Before deciding on Phaser as the framework of choice for the development of CITY, several others were considered. There are many prominent game engines and frameworks available today, where some other than Phaser are Unity, GameMaker, and GDevelop (*Phaser Alternatives and Reviews*). Unity is perhaps one of the most well known of the game engines at one's disposal with a lot of functionality and support (*Unity*). The cross-platform engine supports development of both three-dimensional and two-dimensional games as well as extended support to 27 platforms. Nevertheless, because of its endless possibilities and complexity support, it was viewed as complicated and time-consuming for an uninitiated to enter into (*Unity vs Phaser.io*). Phaser is an easy to use framework perfect for creating and testing a prototype of the concept of informative serious games.

In contrast to the other frameworks and engines, GameMaker is not free to use (*GameMaker Studio 2*). Unity has a personal edition that is available free of charge but with the potentiality to upgrade to a Professional License. GDevelop, on the other hand, are under the MIT license, same as Phaser. GameMaker is similar to Unity in terms of performance and complexability support, thus deemed to comprise of too many unnecessary tools. A framework that is more equivalent to Phaser in regards to magnitude and user focus is GDevelop. However, it aims at facilitating game development for everyone, especially people without previous programming skills, thus

relying heavily on its own desktop application and drag-and-drop features (*GDevelop*). The framework was therefore found to lack the required functionality and support needed to realise the concept of an informative serious game like CITY.

6.2 Other Frameworks Used

Firebase

The game was deployed using Firebase, an application platform for both web and mobile (*Firebase*). It provides the developer with a wide range of services, in addition to multiple payment tiers, where one does not require payment. In the case of the game CITY, the free plan covers the use of testing and development, never experiencing the need to upgrade the account. Other hosting services, such as Heroku and Amazon Web Services were also evaluated (*Heroku Dev Center*; *Amazon Web Services*). However, they were deemed a less suitable choice as they were more time-consuming to implement and set up, and with all their extra services they were considered to be redundant and 'overkill' in the context of this project.

Webpack and Babel

To ensure the game's viability on the web, Webpack and Babel are used. Webpack is a static module bundler that creates a dependency graph of the project and in the case of CITY, generates a single bundle.js file that is inserted into an HTML file making it easy to deploy and use (*Webpack*). Babel, on the other hand, sees to the conversion of new edge JavaScript into plain ES5 JavaScript so the game can run in any browser (*Babel*). Figure 6.2 describes an overview of the bundling process, both for the development phase and for the deployment stage. The main difference is the use of distinct Webpack configuration files. This makes it easy to create separate build configurations for different environments, such as development, testing, and production, and only include code for those specific needs.

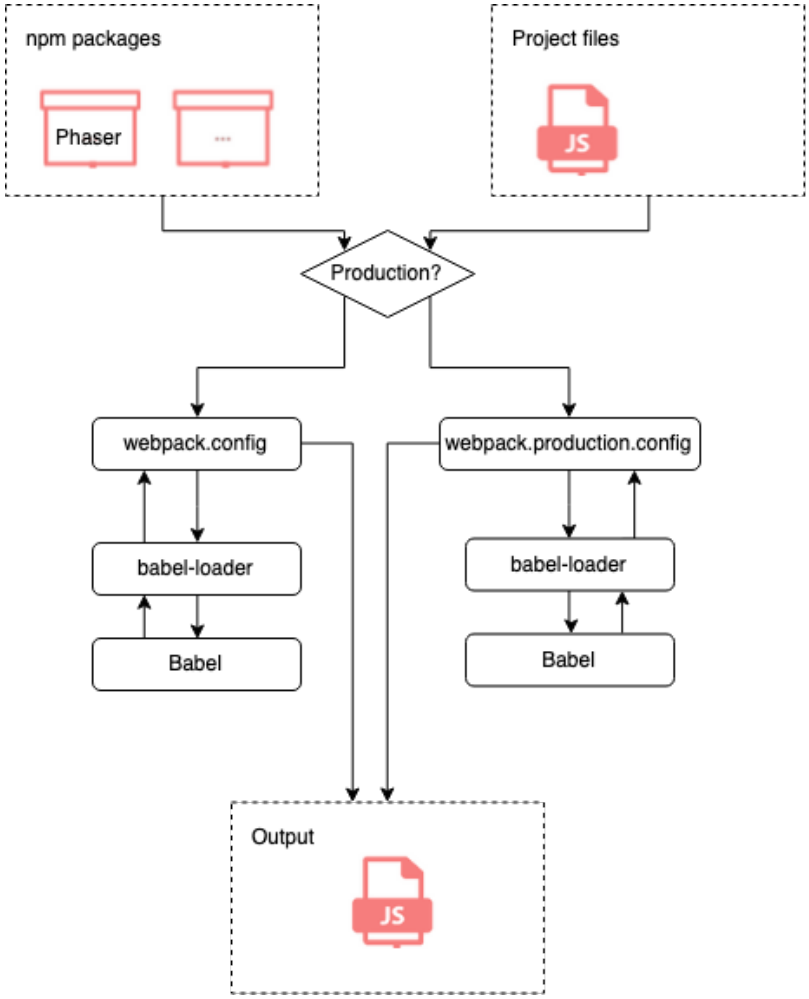


FIGURE 6.2: Bundling overview

Chapter 7

Final Evaluation: NKUL Conference

This chapter describes the first evaluation of the digitally implemented prototype of the informative serious game CITY. It examines the changes made from the previous evaluation, the purpose behind this test, the participants, and how the process was conducted. Finally, it presents the results and a discussion.

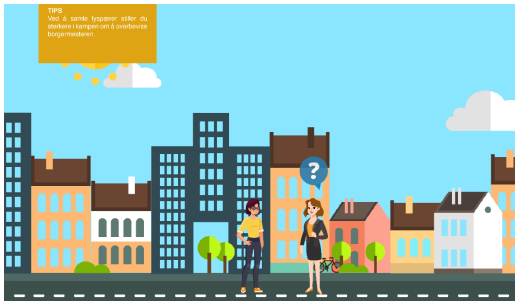
7.1 The State of CITY

In this iteration, the game CITY evolved from a wireframe prototype to an implemented online game. The wireframe worked as the foundation in the development of the digital game, where the story and the chain of events remained the same. The final game can be found at the URL `https://techinthecity.firebaseapp.com` and a description of each level, its learning goal, learning elements, and engagement elements can be located in Appendix A.

Several changes and improvements were made based on the evaluation described in Chapter 5. A description of the modifications and a reasoning for their implementation can be found in table 5.3. In addition to the changes incorporated as a result of the experts' evaluation, the game's graphics were also updated. Figure 7.1 provides an example of changes made to the street levels. The city background, location buildings, and many of the characters have been renewed to facilitate a complete and thorough impression of the

game world. This will prevent confusion and uncertainty in the player. Furthermore, the minigame during the hospital scenario has been improved and its difficulty raised as it was found to be too easy during the evaluation.

(A) Representation of the first street scenario as seen in the wireframe



(B) Representation of the first street scenario as seen in this iteration

FIGURE 7.1: Visualisation of the first street scenario from two separate iterations

7.2 Research Method

7.2.1 Procedure

The first evaluation was conducted primarily during the NKUL conference at NTNU. NKUL is a national conference for ICT in education and learning and is Norway's biggest gathering for teachers who are interested in using ICT in schools. The game was stationed at the Excited stand and teachers and students were encouraged to try during their visit. A computer was placed at one of the stand tables and the participants would sit down in front of it and play. They would receive a quick introduction to the purpose of the game as well as the concept. After finishing the game they would fill out a questionnaire (found in Appendix E).

During the participants' gameplay, the researcher would conduct observations and take notes of comments and behaviours made by the player. This could be feedback on desired functionality, their thoughts on specific elements, challenges encountered, or things they enjoyed.

A pilot test was run before the initial evaluation. This was conducted with three students from NTNU and intended as a verification test before the assessment at the NKUL conference. Their purpose was to uncover flaws and shortcomings in the prototype and the questionnaire.

7.2.2 Participants

The participants consisted of teachers from the conference NKUL and students from NTNU. They were voluntarily recruited during the conference and asked to participate in the test. The teachers were chosen on the basis of their understanding and their proximity to secondary school students. As the serious game CITY is intended for young students', receiving feedback from their teachers holds great value as they have a clear perception of the target group. This evaluation thus facilitates an exploration into their thoughts on using informative serious games to increase younger students awareness and more specifically, if CITY has the potential to intrigue to the target group.

NTNU students and people from the nearby stands were also invited to participate as only a few teachers took the time to try the game. The evaluation was therefore expanded to include the participation of students as well. Although they do not have the same connection to the target group as the teachers, they still serve a purpose in evaluating the game's engagement and learning elements, provide feedback on the usability, and if the game is easy to understand. Their impression speaks to the general opinion of the game.

7.2.3 Purpose

The purpose of the first evaluation is to assess the potential of the informative serious game CITY. The game has moved from being a low-fidelity prototype that was tested and evaluated as described in Chapter 5, to become a functioning digital game. CITY is a working game concept, intended as a mechanism to evaluate the possibility of using informative serious games to increase awareness in young adults. The final product aims at exploring how such games can improve the player's awareness of technology and programming, and challenge the general misunderstandings that exist about the topic. A representation of the final game is found in figure 7.2.

The assessment with teachers and NTNU students provides an opportunity to examine the game elements to determine if they are working as intended. Secondary school teachers have insight into their students learning abilities, their interests, and what they find engaging and motivating. The evaluation therefore aims at identifying elements teachers find to work well in informative serious games and game elements they think their students will enjoy. The game's usability is not the main priority of this evaluation as it seeks to

answer the research questions related to the potential of informative serious games. However, as many participants have clear thoughts on desired functionality and ideas on how things can be improved, usability feedback will be noted down.

The results from the test and the questionnaire will help answer the research questions.

7.2.4 Questionnaire

Questionnaires are commonly used as a research strategy as it provides an efficient method of gathering data. It is well suited in many situations, especially when collecting data from a large number of participants and when measuring attitudes, impressions, opinions, and preferences. The nature of questionnaires makes it easier for the researcher to analyse the collected responses. However, poorly designed questionnaires can have biased or ambiguous questions that make the survey taker frustrated. Additionally, it does not facilitate further questioning or querying into the participant's answers. It is nevertheless a suitable method of data collection when wanting to obtain information from many people. Because of the busy nature of a conference environment, a questionnaire was found to be an appropriate method of data gathering.

A post-game questionnaire was distributed on paper to the participants after they finished the game. It was designed to gather data about the player's background, their impression of the game, the game's engagement and learning value, and who they thought the game would be best suited for. The player was not asked to register personal data, only disclose if they were a teacher or a student.

Four of the questions asks the participant to rate a statement using a 7-scale Likert. This was done to allow the respondents to select the option that supported their opinion best, thus choosing to which degree they agree or disagree with the question. The remaining questions are multiple choice questions with one possible answer. Lastly, the questionnaire ends with a text field allocated to any written feedback the responder might have.

FIGURE 7.2: Images from the final game tested with the participants

7.3 Pilot Test

The assessment was divided into two, the pilot test and the evaluation at the NKUL conference. The small preliminary study was administered as a mechanism to assess the game prior to the conference, allowing for adjustments to be made if necessary. If something were to be missing in this phase of the testing, alterations could be made in time for the larger experiment, securing the chances of a clearer outcome. The pilot test was the first assessment of the game and provided an arena to look at how the player experienced the game, discover unwanted game behaviours such as undetected deficiencies, and learn their ideas on how to improve the prototype before the main evaluation.

The pilot study is also a method of evaluating the post-game questionnaire to receive responses in regards to the questions, their readability, and comprehensibility. It ensures the clarity of the survey and if it manages to collect the desired data.

7.3.1 Observations from the Pilot Test

In contrast to the planned NKUL evaluation, where the aim was to analyse the game's potential, the pilot test focused on the game's usability and functionality as well as the concept and questionnaire. The observations made therefore include the participants' opinion of game functionality, in addition to the overall idea of informative serious games and the used game elements. This was done to ensure the best possible version of the game during the NKUL test.

The test was carried out by three NTNU students in a quiet location, enabling them to concentrate on the task at hand. The process began with a short introduction to the game and their assignment, followed by the participants playing the game. They had been given pen and paper in case they wanted to write their observations and thoughts down. After each student had completed the game, they were given the questionnaire to fill out. Finally, an open discussion was initialised based on observations done by the researcher and notes the participants had made on their own.

During the pilot test, the game exhibited little unwanted behaviour and no bugs other than a missing question during one of the IT scenarios and some

spelling mistakes were observed. Most of the players understood how to interact with the game and the one reporting to have struggled a bit at the beginning admitted to not having read the information boxes carefully. The participant said that it had been difficult recognising what to do with the lady in the first scene because it was unclear how to interact with her. The others had not experienced the same problem, but it was suggested that the question marks signalling the lady's interaction option to be clickable as well.

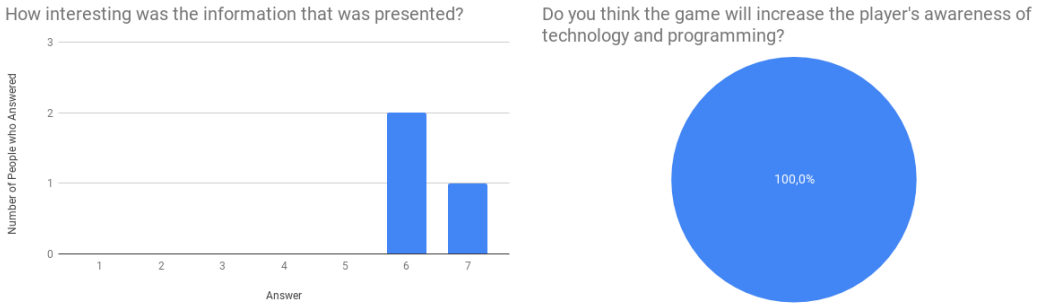
The players' expressed their enjoyment of the minigame during the hospital visit and communicated their desire for a similar game element during the other scenario as well. A minigame related to programming was proposed, in addition to having one of the developers at the IT business create a game the user would test. "*What if you say 'Petter has created a game. Could you help him out by testing it?' and then show them a simple Snake game or similar*." They explained that a minigame helped break up all the text the user would have to read and have them think about something else for a few minutes.

When asked about how they related to the information, it was stated that they found it very interesting. Although all three had a background in computer science and therefore not a representative of the target group, they thought the target group would find the information relevant and intriguing, at least if they did not know it beforehand.

7.3.2 Questionnaire Results

The results from the questionnaire were in compliance with the participants' answers during the post-game discussion. Figure 7.3a visualises the answers given to the question about how interesting they found the information to be. The participants responded with a score between 6 and 7 where 0 is not interesting at all and 7 is very interesting. When asked about their impression of the game's difficulty when considering the target group, the respondents seemed to be of a collective opinion. They all thought it was a bit easy compared to the students' skills.

The participants were asked who they thought the game would be most suitable for both in terms of age and gender. All were of the opinion that the game would be interesting to both girls and boys, and all but one found the game suitable for both lower and upper secondary school students. Figure 7.3b demonstrates the respondents' verdict in terms of the games potential as



(A) How interesting did you find the information? From 1: very boring to 7: very interesting

(B) Can the game be used to increase awareness of technology and programming?

FIGURE 7.3: The pilot test participants' opinion to two questions from the questionnaire.

a method of increasing the player's awareness of technology and programming. All thought the concept would raise the user's understanding of the topic.

7.3.3 Discussion

The pilot test was performed with a few participants who were not part of the target group. It is therefore worth noting that the results acquired during this test might not reflect the target groups view or be a good indication that the game accomplishes its intended goal of raising awareness in the player. Nevertheless, as previously explained, the purpose of the pilot test was to receive feedback before the actual completion of the evaluation. This initial study allowed for the opportunity to examine the flow of the test, discover unwanted functionality in the game, and receive feedback on how to improve the usability so it would not get in the way of the main evaluation's goal of analysing the concept.

Initial results revealed that the overall concept and story seemed to engage the players, and all agreed on the value that the presented information gave. They liked the idea of having minigames within each scenario to maintain the player's engagement in between information gathering.

7.3.4 Changes Made as a Result of the Pilot Test

The changes suggested during the pilot test was organised into a list and prioritised before being evaluated for implementation. Table 7.1 illustrates the minor modifications that were made before the NKUL evaluation.

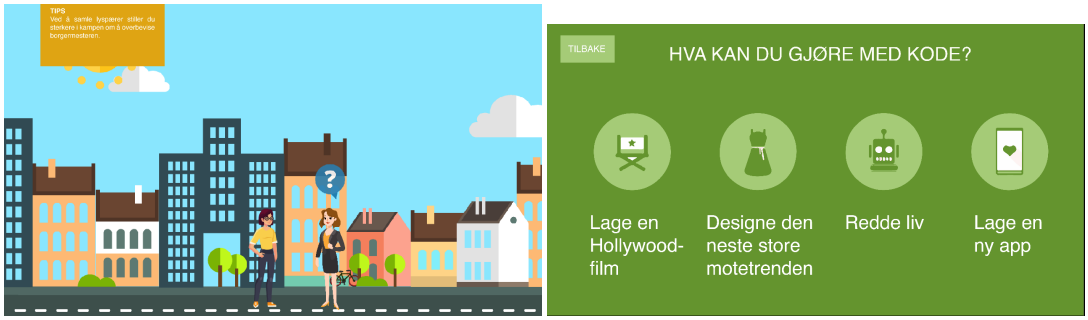
The questionnaire was also evaluated, and since it was thought to be acceptable by the test group, no changes were made.

ID	Scenario	Description	Reason
1	IT Building	The image of the man was flipped to make it clearer that he had two separate text entries	Some participants had not realised that the man explaining the various aspects of programming consisted of two separate texts
2	All Street Levels	Increased the area to which it is possible to enter a building	A user found it difficult to walk into buildings
3	Battle	Created a nicer end scene	One player thought the end scene was a bit unappealing and that it would be more satisfactory to win/lose if the scene would reflect that
4	IT Building	Made a minigame for the IT scenario	The participants found the IT scenario somewhat long and less engaging than the Hospital scene because of the missing game
5	Where needed	Update images that were pixely	The testers found some of the images containing text to be less comfortable to read
6	Where needed	Updated information presented to the player	Removed spelling mistakes

TABLE 7.1: Minor changes made to the game CITY as a result of the pilot test

7.4 NKUL Conference Results

In the pilot test evaluation (Section 7.3), CITY was examined and judged to be of satisfactory qualities in regards to its usability and functional behaviour. The assessment procedure therefore continued as planned, resulting in the execution of the second phase during the NKUL conference.



(A) Representation of the question mark that signify that the object is interactive.

(B) Representation of the IT scenarios that lead to some misunderstanding

As a consequence of the feedback received during the pilot test, minor alterations were made to the game before the NKUL evaluation. These included correcting spelling mistakes, updating images, and adding a minigame to the IT business. These changes resulted in the final version of the game and are the product that has been tested during the NKUL conference and the final evaluation described in Chapter 8.

7.4.1 Observations

During the participant's interaction with the game, observations where made and written down as notes to gain further insight into the game's impact on the player and if any unwanted behaviour not caught during the pilot test revealed itself.

An obstacle that seemed to arise in almost all of the test subjects was their mental model of how to interact with the interactable objects. Many wanted to click on the question marks meant to signalise the object's active state (see figure 7.4a), while others tried to walk towards the item hoping it would lead to a change in the game state. It was suggested to add functionality to the symbol as well as including a hand cursor symbol when moving the mouse over clickable objects.

A misunderstanding arose during an IT scenario depicting an image with a header saying "What can you do with code?" (Figure 7.4b). The intention behind this scenario was to demonstrate and inform the player of the various aspects code can be used in. Unfortunately, this was interpreted as a question the player thought she or he would have to answer, leading to many participants clicking on the non-interactable image.

After the pilot test, it was decided to incorporate a minigame to the IT location similar to the one found during the hospital visit. The minigame became a time-based challenge where the user is tasked with removing the phones present on the screen. The clock counts down as the player tries to click as fast as possible to remove all the object. If all the items are destroyed before the time is out, the user receives a light bulb to use in the battle against the mayor. The minigame was included in one of the existing IT scenarios as a game created by one of the developers at the office. Many of the participants expressed their delight when playing the minigame and stated that they liked the idea of using small games to maintain the user's engagement during the location visits.

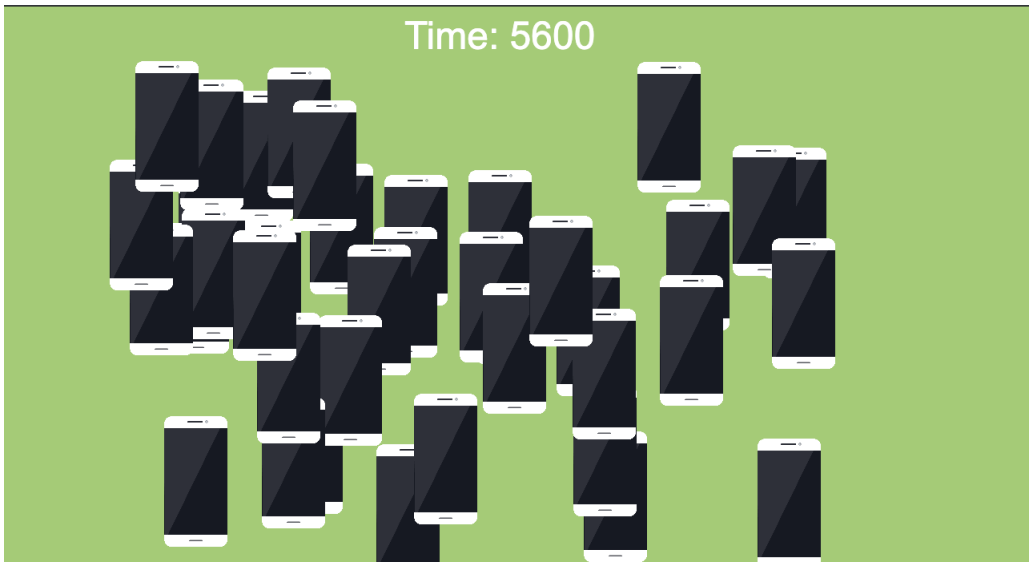


FIGURE 7.5: Screenshot from the added minigame in the IT scenario

7.4.2 Questionnaire

The results from the post-game questionnaire provide insight into the players' opinion of the game and its specific elements.

Overall Impression

Figure 7.6 shows the overall impression the participants had of the game. The players have responded by providing an answer from Very Poor Impression (1) to Very Good Impression (7). The table reports on the average score that

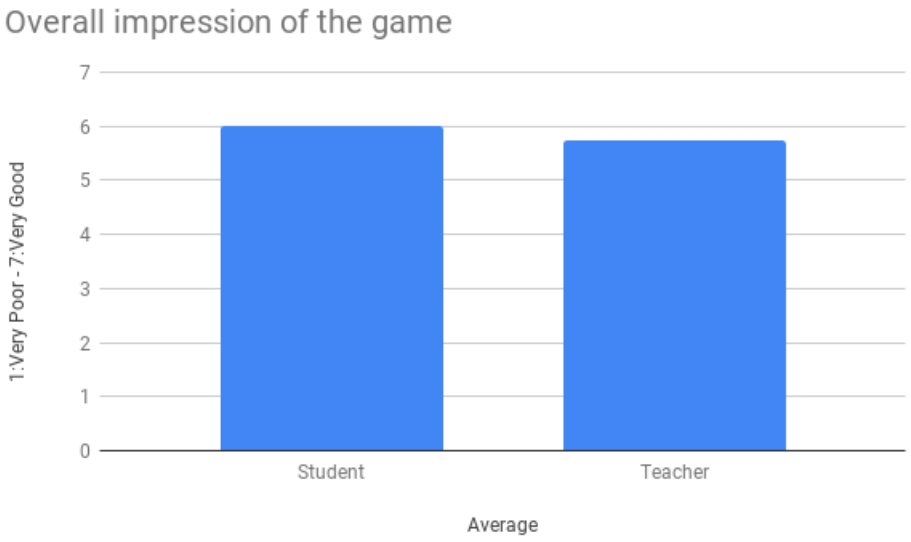


FIGURE 7.6: The participants' average impression of the game. Divided between students and teachers

is given on a scale of 1 to 7. The student score was 6, whereas the teacher score was 5.7.

Age and Gender

Figure 7.7 and 7.8 gives a representation of the participants' answer to who they deemed the target group to be. There is an interesting divide between teachers and students in regards to the suitable age level for the game, as seen in figure 7.7. The teachers are more open to using the game in both upper and lower secondary school, while students at NTNU think the game is most appropriate to lower secondary school students. Figure 7.8 show that most of the respondents thought the game to be interesting to both girls and boys.

Game Elements

To analyse the players' experience of how engaging the game was, on what level of difficulty it was found to be, and how interesting the information was, a 7-point Likert scale was introduced in the questionnaire. Figure 7.9 represents the average score of how engaging students and teachers found the game, 1 being very unengaging and 7 being very engaging.

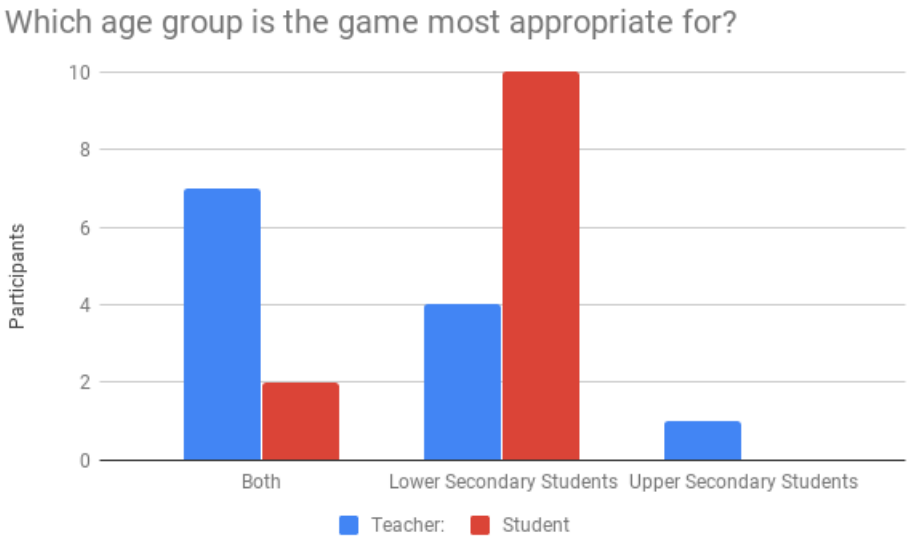


FIGURE 7.7: What the respondents thought to be the game's appropriate age group

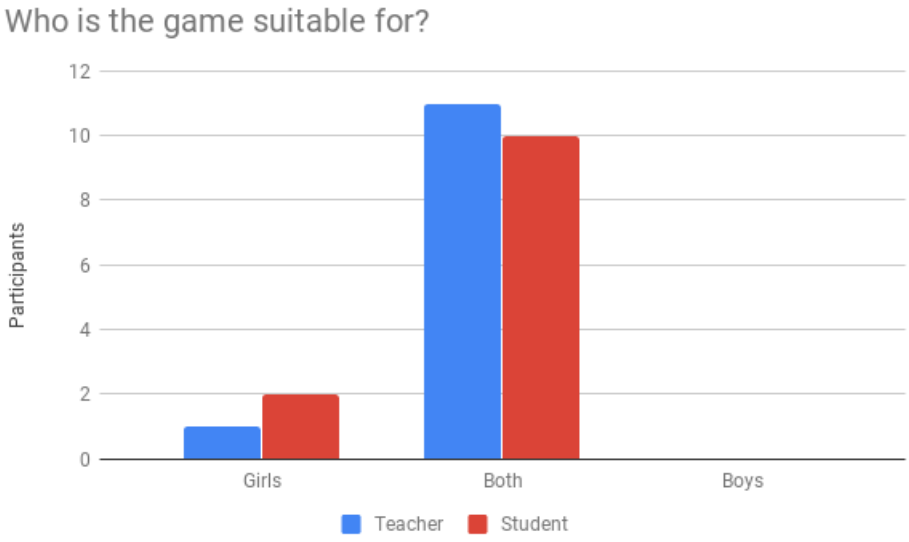


FIGURE 7.8: The gender the respondents thought would enjoy the game the most

Engagement in a game is often tied with the degree of difficulty experienced, and the participants were therefore asked how challenging they found the game, 1 being too difficult, 7 being too easy. From figure 7.10 it is clear that the respondents thought the game to be somewhat easy, with the majority of students reporting that it was a "bit too easy". However, 5 participants thought it to be at an appropriate level of challenge.

The questionnaire revealed that the test subjects found the information to be

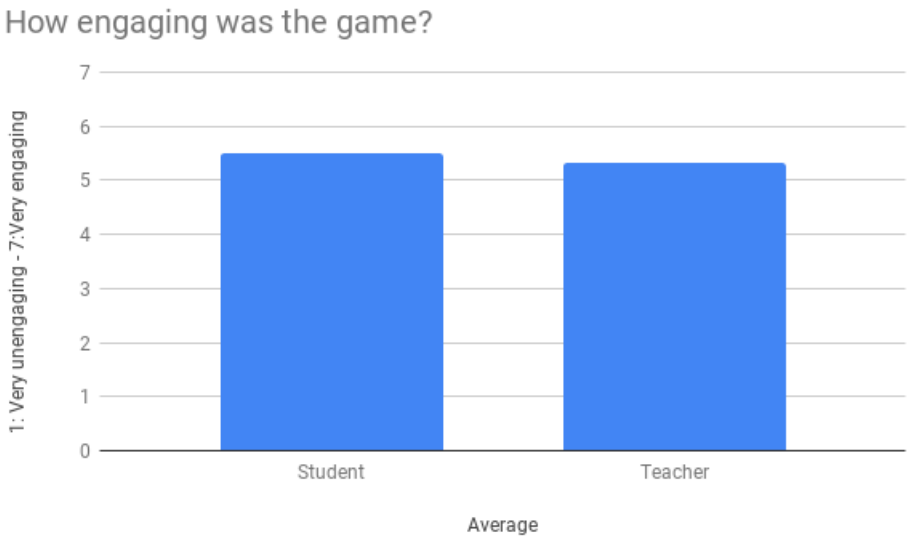


FIGURE 7.9: The experienced engagement level

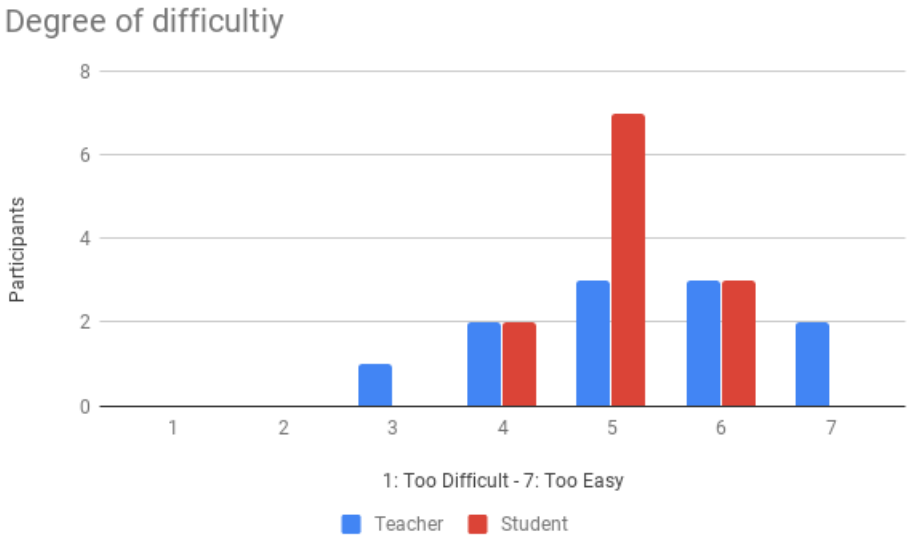


FIGURE 7.10: How difficult the participants found the game to be with the target group in mind

interesting. The teacher group rated the presented theory to be on an average 5.41 interesting, and the students 5.91. Similar to the other questions, this one was also reported on a 7-point Likert scale, where 1 was Not Interesting at All and 7 was Very Interesting.

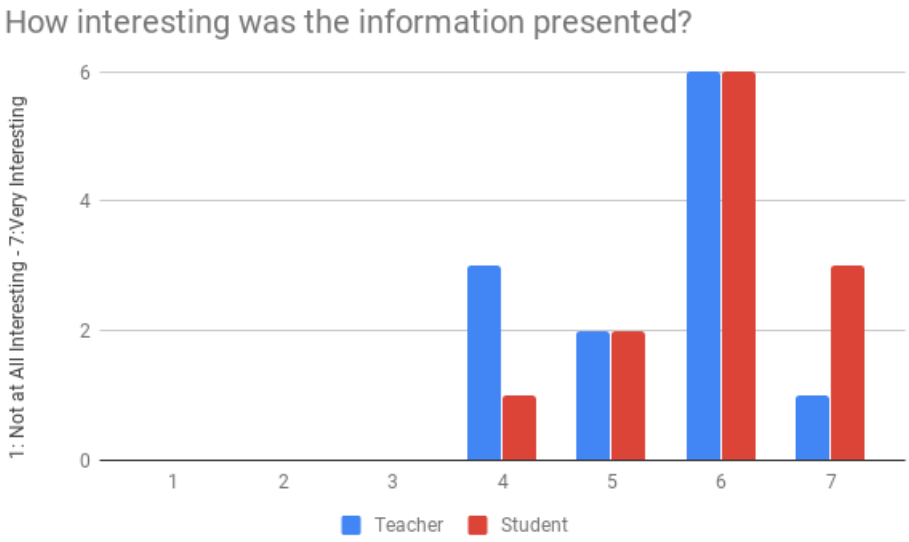


FIGURE 7.11: The respondents thoughts on the information presented in the game

Raising Awareness

All the participants thought the game could be used to increase the awareness of a user. Some stated that this was if the player did not have previous knowledge of the subject.

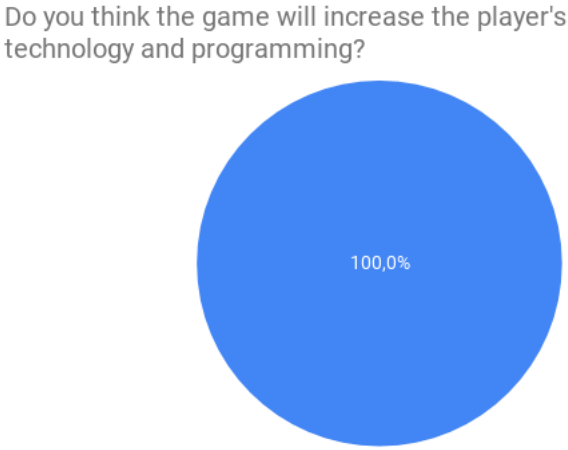


FIGURE 7.12: All the participants thought the game could be used to raise awareness of technology and programming

7.5 Discussion

In this section, the results collected from the initial testing of the digital prototype of the informative serious game CITY will be discussed. By comparing data from observations made during the tests and the respondents' questionnaire answers, lines can be drawn to paint a picture of how the game is perceived by teachers and students alike. The discussion will focus on who they regarded as the target group, the game's difficulty level, and their impression of engagement and learning aspects.

7.5.1 Perceived Target Group

It is interesting to see the divide visualised in figure 7.7, where teachers and students seem to have two distinct opinions of what the appropriate age group for the game is. Almost half the teacher group believe the game to be suitable for upper, as well as lower secondary school. The students, on the other hand, are dominated by the opinion that lower secondary school is the most acceptable group for the game.

It is difficult to conclude which of the groups are right without further evaluations with both secondary school groups. This will be presented in Chapter 8. For now, one could argue that the teachers have more knowledge of their students interests and game preference since they are a big part of these students school day. Contrarily, students at University are closer than most teachers in being the same age as the groups in questions. For some, it might only be four years since they were in lower secondary school. Additionally, they often have a better understanding of technology and games than teachers, thus being able to evaluate the game from a lower grade student's point of view. Nevertheless, in the expert evaluation of the prototype, the upper secondary school student expressed interest in playing the game even though it might become a better fit for a lower secondary school student.

A previous interview with upper secondary school girls revealed that they do not enjoy games specifically aimed at girls. Games for girls often present females stereotypically, assuming that girls cannot like the same games as boys. The interviewees stated that they wanted games that were neutral to both genders. When looking at figure 7.8, we see that out of 24 participants,

only three thought the game was only for girls. The remaining 21 respondents found it to be appropriate for both genders suggesting that game is considered gender neutral by the test subjects.

7.5.2 Level of Difficulty

An appropriate and increasing level of difficulty is central when creating an entertaining game. The concept of flow is tightly coupled with this idea, where a balance must be found to keep the player interested in the game. Figure 7.10 presents the participants' view of the game's perceived difficulty. Again, there seems to be a divide in the opinion between the teachers and students. The teachers' result is more parted than the students', ranging from 3 to 7, 1 being too difficult to 7 begin too easy. As a result, they have a mean average at 5.27 in recognised difficulty, compared to the students at 5.08. The overall result indicates that the game is somewhat but not too easy.

The primary focus of the game is on providing information and increasing the player's awareness. If the player struggles to complete a location scenario, it might result in her losing interest in the information or in the game itself. The user will be too anxious in trying to figure out how to proceed in the game, consequently becoming unable to pay attention to the conversations or other provided pieces of knowledge. One could argue that to maintain a suitable game for all, the difficulty must be controlled.

By analysing the statistics from figure 7.9 and 7.10, there do not seem to be a clear correlation between the game being considered easy and the experienced engagement. Although the game is thought to be too easy by some, 7.9 show that it is still found to be entertaining. This might suggest that an information game like CITY does not need to be difficult to encourage the player to play on.

7.5.3 Engagement and Learning Aspects

The serious game CITY was created with the intention of raising awareness of technology and programming. Figure 7.12 gives an answer to the respondents' opinion in this matter. The result shows that the participants all considered the game to have this ability. Nevertheless, it is noteworthy to recognise the fact that this is only the opinion of the participants, not an

evaluation of whether or not they experienced this change themselves. The questionnaire does not evaluate the actual behaviour change or learning outcome undergone by the player. Rather, it seeks to analyse their impression and perception of the game to see if it can have an effect on the target group.

Figure 7.6 and 7.9 visualise the test subjects reaction to the game. With an average of 5.5 and 5.3 for students and teachers, respectively, the game was well received by the participants. When comparing the groups' answer to the question of how interesting they found the information, we see a similar trend. The students appear to find the game and the information more fascinating and enjoyable than the teachers. One possible reason could be that students are closer in age and situation to the target group than the adult test subjects. They might identify with the values presented in the game to a bigger degree than the teachers.

Furthermore, several of the participants, both teachers and students, noted that many teachers have an apprehensive approach to technology and programming in school. One teacher stated that they shy away from tasks that involve educating the students about programming, often because of their own missing knowledge and understanding of what it is. They use technology at almost the same rate as the student generation, but they might not have the same motivation and desire to learn how it works (Jiang, 2018).

Looking at figure 7.9 and 7.11, we see that most of the respondents felt the game and its content to be interesting and engaging. Nonetheless, players with an extensive background in games compared to players who almost never play might have a different experience of the game. In a post-game conversation with one of the student participants, it was revealed that he perceived the game to be a bit unexciting. The discussion uncovered that he was a gamer and liked to spend time playing video games. In research done by Dickey (2011), a similar experience occurred. In her evaluation, two participants who considered themselves gamers tried to pick the game environment apart. They proclaimed that they approached the game as they would any other non-serious game. This suggests that gamers might be more centred on the engagement aspects, rather than the learning elements in a game.

When talking to another participant of the test that did not consider himself to be a gamer, it became clear that he saw the game as engaging and something that made him think. These results might imply that non-games are more susceptive to informative serious games because they are more intended on learning than on playing the game.

Chapter 8

Final Evaluation: Expert Assessment

In this chapter, the final evaluation of the informative serious game CITY is described. During the test with both teachers and students at the conference of NKUL, the game was regarded as satisfiable both in terms of usability and learning and engagement outcome. It was therefore decided to continue with an evaluation that included experts and the target group. The version of the game that is tested in this chapter is the same as described in Chapter 7 after the pilot test. A full description of the final game can be found in Appendix A.

8.1 Research Method

The main evaluation consisted of a series of tests and interviews with female secondary school students and experts in game design and recruiting. As part of the previous assessment with teachers and students at NKUL, the game had been deemed engaging and a suitable device in raising awareness of IT. This chapter describes the evaluation of CITY with the target group and experts, examining the features they find most motivating and educational.

8.1.1 Purpose

The motive behind the main evaluation is to assess the game CITY. It aims at investigating the game's potential as an alternative learning device, focusing on identifying the learning and engagement elements that work well. The game is still a working concept rather than a fully fledged application ready

for production and hence seeks to focus on evaluating game mechanisms, learning objectives, and the user's interest in playing such a game. The results will contribute to answering the research question RQ.1, RQ1.1, and RQ1.2.

The usability of the game is not evaluated in this assessment, but as some users might have feedback or ideas on how to improve it, it will be noted down. This will make it possible for others using this thesis as a guideline when creating an informative serious game to learn and benefit from previous findings or in case of further development.

8.1.2 Participants

The evaluation was conducted with three lower and four upper secondary school females, one game design expert, and one recruitment expert working at The Girl Project Ada. Table 8.1 provides a structured overview of the participants and their role during the assessment. The tests were held separately in their respective groups, resulting in four sessions. One with each expert and one for each age group in secondary school.

The participants were selected based on their background and previous experience with games and insight into secondary school students engagements. This was done to ensure the quality of the results and their relevance. The game design expert was chosen because of her prior involvement with the project in the prototype evaluation described in Chapter 5. The upper secondary school students had also taken part in the project earlier, both as interviewees and participants of the workshop held during the specialisation project. Furthermore, one of these representatives had evaluated the prototype presented in Chapter 5.

The reason for selecting these participants derive from the desire to have a continues development of the concept and utilise the insight and knowledge these subjects have of the project and the idea. Many of them have followed this research from the start and learning their thoughts and options are valuable and a resource for further enhancing the game.

Participants	Role
Lower Secondary School Student (Main Target Group)	Evaluate the game and share their experience of it. Provide feedback on the possibility of using such a game to raise awareness of IT
Upper Secondary School Student	Evaluate the game as possible recipients. Share their insight on how the target group would assess the game and supply the researcher with an understanding of how well the game mechanics work to increase the player's awareness
Game Design Expert	Evaluate the game based on their expertise in game design. Provide insight into how well the game mechanics work to raise awareness of the topic presented
Recruitment Expert from The Girl Project Ada	Evaluate the game based on their expertise from working with recruiting girl to technology studies at NTNU. Share their knowledge of what younger girls find interesting with IT

TABLE 8.1: Overview of the participants and their role

8.1.3 Procedure

The evaluations were all administrated in the same group room at NTNU. This ensured similar testing conditions for all participants, as well as a quiet and comfortable environment. The test started with friendly small talk to generate a calm and open atmosphere to remove any nervousness the participants might feel. The participants were then asked to read and sign a consent form describing the purpose of the study, their role in the test, affirmations of their anonymity and their right to withdraw their consent at any time. A brief oral introduction was given to the project and the game concept following the signing of the consent forms.

Before the game session started, it was made clear that this was not a usability test. The game is as a concept prototype, and the goal of the evaluation is to assess its potential, not its functionality. A short introduction to common usability obstacles observed in previous evaluations was given

to ensure the participants' focus on the game's ability to educate and raise awareness. They were urged to click the characters, not the bobbles indicating their active state and asked to use the mouse for most of the actions expect walking. After the testing, a semi-structured interview was held with the players. The interview guides can be found in Appendix F.

To ensure the participants' privacy, all notes were taken by hand. They had been informed of their anonymity in the consent form and during the short introduction to the session. After the testing and interviews were conducted, the test subjects were thanked for taking the time to participate. In addition to snacks made available during the test, the secondary school students were given a gift certificate for 300NOK for joining the evaluation.

8.2 Results

8.2.1 Lower Secondary School Students

This section presents the results from the interviews with the lower secondary school students.

General Impression of the Game

Upon finishing the game, the girls were asked what their initial impression was. One exclaimed that she thought it was excellent. "*The information was easy to understand*." Another stated, "*I liked the idea of using a game to motivate learning*." It was also said that they enjoyed the minigames and that winning the game was fun. They noted that the information was convincing and comprehensible. When queried about whom they thought the target group should be, they all agreed that lower secondary school would be a good fit. Both girls and boys could play it, but they liked that it was created to be "extra motivating to girls." To ensure that boys also found it interesting, they suggested incorporating a feature to select the gender of your character before the game starts.

The participants were asked in which environment the game should be played in, and all thought school to be the best location. "*I think our science teacher could have used this*." They were asked if they had the opportunity to take the elective course IT but stated that their school did not provide it anymore.

It was also suggested to use the game as homework, which they found to be a more exciting way of learning than having to search for information on the Internet. They emphasised, "*The information was very well explained. We wouldn't have to browse through tons of irrelevant theory on Wikipedia, for instance. Everything we need is right here.*" They also expressed their appreciation of the design, thinking it was fitting. It was, however, proposed to add a method to go back to earlier levels, in case one forgets the code to the city hall.

Engagement Aspects

When asked if the game was entertaining, the girls answered that they thought it was. They especially liked the minigames, saying the "phone game" at the IT business was the most engaging. "*The countdown was a bit short making the game a little difficult, but it has you coming back to complete it.*" To enhance the overall experience of the game, they suggested adding more minigames, preferably something with learning objectives combined with it. An example the girls gave was a minigame where the player would assemble a computer. They seemed eager to try this.

The minigames were, however, not the most engaging game element, as this was found to be the dialogue choices, or the consequential play element. They explained that being able to choose what to say and what action the character should take empowered them as players. It made them excited to discover what the response would be. They also liked that they were able to click on the characters in the buildings, thus being given the ability to select the person they wanted to talk to, rather than being presented with someone.

They viewed the storyline as an essential aspect of the game, always leading them further along. "*It's what the game is based on. It follows you from the start to the end, making it easier to learn as you see the overall context at every step.*" When questioned about the light bulbs and whether they found it to be an engaging element, one said that she had thought about it when she found the hidden one at the IT business, while another confessed to having forgotten about it until the battle.

Learning and Awareness Raising

The participants were asked if they had previously heard about the information that was presented in the game. All replied that although they knew

much of it beforehand, they had not thought out it in that context before. One said, "*I haven't thought about clothes or a pacemaker to be part of technology. Neither to what extent hospitals use it*." Another stated, "*It's a new way of thinking about technology.*" When queried about how interesting the information was, they said that it was fascinating and easy to follow. "*Many sites and articles on the Internet is so long and have difficult language, but the language here was simple and understandable.*" To the question, "how do you feel about the length of the text," they replied that sometimes was too much, especially when the dialogue whet back and forth, without much interaction from the player. "*But at the same time, it's so easy to understand, so it was fine.*"

When asked if they now knew more about technology and programming, it was stated that they did, particularly on the subject of how it is used and how it is made. One student shared that she had not thought about how technology can lead to new jobs even when it eliminates others. Furthermore, they explained that the game made them think about technology and programming differently than before. "*You get to see that it's more than just creating computers. The domain is so much more than what people might think*."

During the discussion about which learning elements were most useful and most educational, several objectives were mentioned. The text boxes were the actual elements that contained the information, while the scenarios like the smartwatch were fascinating because it was more than just text. One participant said, "*I enjoyed the concrete examples that were relatable to my own life*." While another stated that being able to choose what to say in the discussion was most beneficial. She was asked if the discussion with the mayor was where she learned the most, but she disclosed that the locations were best at teaching new information because of the appropriate balance between images, text, and the player's option in selecting what to click on.

The girls were asked if they wanted to learn more about IT, and all responded yes. "*It's very relevant to know something about technology and programming later in life. It's so pertinent*." One stated that she wanted to learn more about it at school, explaining that they had not had any training in programming or what technology was. Another then replied that they had made a simple game but that they had been thrown into deep waters and asked to do something without instructions first. In response, they added that CITY could be a motivator to both teachers and students when starting out exploring technology and programming.

Proposed Improvements

Before the interview's end, the participants were asked if they had any suggestions for improving or expanding the game. Would they like to visit more locations and was there other ways of presenting the information? They answered that a location not directly linked to technology and programming would be educational. "*Something like a farm. They use a great amount of technology, but no one ever thinks about that*." A police station was also proposed, with emphasis on that it would be fun to solve a case using some particular type of technology. When considering various methods of presenting information, a quiz was said to be engaging. "*You have to solve the quiz before you can move on. Then you also test yourself to see if you actually have learned something*." The girls were also eager about the idea of having a final page with resources to learn more about the presented topics and on how to proceed to learn to program. "*Many people don't know where to start. Even the once who are interested in learning*."

8.2.2 Upper Secondary School Students

This section describes the results from the interviews with the upper secondary school students.

General Impression of the Game

The group interview started with the girls being asked what their impression of the game was. One participant answered, "*I think programming is difficult and I'm kind of scared of it, but this was fun! It felt like I was learning something without even knowing it.*" The others replied that it had been nicely created and that many games often have poor graphics that weigh it down, but this was not the case here. "*Leaning something is a plus and also to be able to see everyday objects in a new context. I hadn't considered clothes and warmth to be technology.*" They mentioned that the game was more educational and exciting than if they had been presented the information at school. They had heard from friends taking the IT class in school that they found it to be tedious and unengaging. "*This is a more interesting way of learning about technology*."

When asked whom they thought the game was most appropriate for, they answered *"younger than upper secondary school."* They stated that students at

the age of 10-13 would have many benefits from playing the game. On the other hand, one of the girls said that she would have played it even at their age. "*The game is good for people who think technology is abstract and difficult*." They liked the idea of the game being created for girls and stated that boys that age might be too into gaming, thus having enough previous knowledge of technology and programming to want to play it. It was suggested to target it toward teachers as well, underlined by one of the participants, "*Many teachers don't know where to start so it could be a great tool they could use as a starting point when introducing technology to us*." The participants proposed to use it at school, at educational fairs, research days, explaining that it would work as an excellent opening into IT.

Engagement Aspects

The test subjects were asked what they thought of the design, and one answer was that the colour usage appealed to them. "*Simple and dull colours are tedious to young children*." Another feature they enjoyed was the gradually darkening of the sky as the story transpired. "*It made the storyline more complete.*" In terms of the game's difficulty, the upper secondary school students found it to be a bit easy. "*This is, of course, very dependent on the audience. An 11-year-old might find it to be more difficult*." To increase the challenge-level, they suggested using class levels, scenarios specifically designed for each grade. Some thought a quiz at the end could help raise the difficulty level or having the various people at the locations be designed with different obstacle levels. "*You could have people with red bubbles above them, signalising a more difficult level than someone with a blue bubble*."

When asked if the game was entertaining, all answered that they thought so. The minigames were found to be the most engaging elements, in addition to being able to go inside the builds to see how technology is being used. The "phone game" was the most entertaining minigame, and they mentioned that it was a nice break from the reading. They also found having to remember things from previous parts in the game to be motivating, as it made them feel accomplished when using it to solve puzzles. The story was also deemed to be an essential part of the game and a central element in generating motivation. "*Without a clear objective to the game, I see no reason to play it, but in CITY I was like: 'Oh no, the mayor has taken all the technology. I must stop him'*."

Learning and Awareness Raising

The participants explained that there was no wow-experience when reading the information because they had some previous understanding of it. However, they stated that it got them thinking. *"The information made it less scary and foreign, and more interesting."* Many said they wanted to learn more about IT, especially about programming, and that the information provided could make it easier to acquire that skill.

When questioned about the most effective learning element in the game, the answer was talking to the other characters. "*It's more interesting to hear a doctor say something than reading 'Here at the hospital...'*." The game's flow and clear connection between the goal and the presented information were mentioned as well and said to be engaging. They felt that they knew more about IT after playing the game, saying that the discussion with the mayor was especially interesting. "*It was relatable.*"

Proposed Improvements

During the group interview, several enthusiastic suggestions for improving and evolving the game was put forward. The girls thought a third location would be a nice supplement, making the game longer and therefore a more suitable learning tool to be used during class. "*Maybe a farm, or a space station that you travel to*." The space station idea was however, put aside in favour of an airport because of the unrealistic scenario it would present.

8.2.3 Game Expert

This section describes the results of the interview with the game expert. She had previously participated in the pilot test as one of the experts on games.

General Impression of the Game

The game expert's first comment after playing the game was "*It's very engaging. This is a feeling you can count on to emerge in the target group.*" She emphasised that the game made her reflect on technology in a way she had not previously done and that it made her stop and think. When asked whom she thought to be the best age group for the game, she answered that she

believed both lower and upper secondary school students to be appropriate. "*The upper grades can get a glimpse of what they can choose to study, while the younger students can have their interest for technology kickstarted.*"

She was of the opinion that the game would go well with both girls and boys, but that it was particularly accommodating toward girls. She pointed to the use of many female characters and the female-specific information such as examples of using technology in fashion and health. When discussing the game design, the game specialist found the design elegant and easy to navigate. "*It's not confusingly big, and the characters are a good representation of people working in the respective fields*."

Engagement Aspects

When asked about her opinion on the game's level of difficulty, she answered that she thought it to be suitable. She declared that it was easy at this point but that it was more important that the game made the students stop and think than have them struggle to complete the game. If it was desirable to raise the challenge level, more difficult questions could be included, or the dialogue choices could be made harder.

During the conversation, she stated that "*The game was entertaining. I was curious to see where I could go and what I'd discover there*." When queried on what the most motivational element was, she replied the dialogue options. "*Allowing the player to select what she wants to ask or say makes her more conscious of the choice she is making.*" Furthermore, she found the storyline and minigames engaging elements that are useful in classroom settings. "*The storyline is nicely integrated with the game mechanics. When it gets darker and darker as the story develops, the player gets a sense of urgency and the need to move along.*" She also said that she found the mayor to be condescending in a good way. "*He was provoking, egging you on to want to defeat him*."

The light bulbs were seen as a suitable method of keeping the player up to speed on the advancement made, especially during the debate with the mayor. By collecting them and receiving them at various locations in the game, it created a sense of continuity.

Learning and Awareness Raising

When asked what element was most important in raising awareness of IT, she replied the dialogue choices and the following information. *"The player has to actively take a stand, making it more compelling to see the outcome."* To the questions "how interesting was the information?", the game expert answered, that she found it very engaging but that it depends on the player. "*You'll have the ones who are already interesting. They will want to know even more. Then you'll have those who haven't considered it, who might get an eye opener, and lastly, there's those who've already decided they don't like it. They'll probably try to rush through the information and focus on the game elements*."

She mentioned that none of the information presented came as a shock to her. However, if she had had the opportunity to hear it when she was in lower secondary school, she would have found it very motivational. "*Even if the player knows the information beforehand, seeing it under new circumstances will have them reflect on it differently than before.*" When asked if she thought the game would change someone's opinion or outlook on IT, she said that yes, mainly because of the way the information is made available.

Proposed Improvements

The game expert believed the game to be a nice supplement in a school class, pointing to research on how games often are used to stimulate discussions afterward. She therefore suggested creating a teacher's guide to facilitate further discussions on the topic of technology and programming. Video interviews with real people were also proposed, as well as having resources to guide interested players in the right direction for learning more. Her last suggestion was sound and music, as they can work as powerful instruments in generating excitement and feedback on actions.

8.2.4 Recruitment Expert from The Girl Project Ada

This section presents the results from the interview with a member of The Girl Project Ada (TGPA). The interview aimed to benefit from the participant's insight into the recruitment of girls to technological studies.

General Impression of the Game

The participant of TGPA thought the game to be a pleasant way of learning about IT. "*The game presents information using an interesting approach. A recitation of what technology is would only have been tedious*." She expressed how she deemed it to include a wide spectre of areas within IT with the potential for expanding it further in the future.

Her opinion of the target group was centred on primary school and early lower secondary school. She did however state that with minor changes and some expanding, the game could be used by upper secondary school students as well. In terms of gender, she observed that it was designed to target girls, but that boys would want to play it, although they might not find it as engaging as girls. "*Girls are more willing and interested in reading in games, while boys need something to happen all the time*." To facilitate more room for male players, she recommended including more variety and more activities.

When asked where the game could be played, she replied at school and TGPA events. "*It's easy to showcase, but it might be a bit too long now to be played at a stand. Nevertheless, TGPA has codehubs with younger girls where it could be used to give the participants an introduction to what technology and programming are.*"

Engagement Aspects

During the discussion of the engaging factors of the game, the recruitment expert revealed that she thought the game to be exciting. "*The concept was captivating, and I thought the minigames were a good way of maintaining the motivation during the play. There could be even more of them.*" Despite the fact that she enjoyed the minigames, she found clicking on objects and the characters to be the most engaging game mechanics. She also mentioned choosing what to say as part of the top best engagement elements.

When inquired on the use of light bulbs as an engagement element, she answered that she had not given it much thought until the battle with the mayor. Then it was an organised system to keep track of her status. She continued by saying that it had been motivating to gain one after completing the hospital minigame and unfortunate when she was unable to do so after losing the IT minigame.

Learning and Awareness Raising

Similar to the other interviews, the representative from TGPA was asked what her opinion was of the information made available in the game. She answered that she found it to be a good mixture of relevant information that girls would find interesting. "*It covers a broad aspect of technology in a short time, demonstrating that it can be so much more than just programming and websites*." To make the game more engaging, she suggested making the information a more significant part of the minigames. Moreover, she mentioned that much of the information in CITY was related to what TGPA uses to promote interest in IT. She added that the game could include supplementary examples on why we need women/gender-balance in technology fields.

The learning objectives she found to be most effective in increasing the player's awareness was the conversations with the characters, as well as the debate against the mayor. "*It was fun to be able to use what I had learned during the game.*" When asked if a quiz should be included at the end of the game to test the player's new knowledge, it was said that this would ruin the flow of the game. "*The battle with the mayor is an essential part of the game, but if the quiz was prior to the end discussion, as a challenge the player would have to face before the final 'boss,' then I think it could work.*"

Proposed Improvements

Several suggestions were made during the interview on how to improve and further enhance the game experience of the player. One thing that was pointed at was the role programming was given. She liked how it was presented as something everybody could learn, but she missed being able to try it out while playing. It was therefore proposed to implement a short code assignment to boost the player's confidence in regards to programming. Subquests were also suggested, having the player help characters solve their problems and become aware of technology through their actions.

8.3 Discussion

This section presents a discussion of the obtained results from the final evaluation with the experts. The discussion focuses on the engagement and learning elements in the concept game CITY, the game's target group, the difficulty, and changes proposed by the evaluators.

8.3.1 Learning Objectives

A set of learning elements were identified in chapter 3 (table 3.3) as being especially suitable when designing serious games. The ones deemed relevant and beneficial in the context of the serious game CITY was incorporated as learning objectives in the game. The participants in this assessment were then tasked with evaluating these elements to be able to answer which can be considered to work well when designing informative serious games aimed at awareness raising.

Consequential play was deemed by the players to be the most helpful game element to increase their understanding of technology and programming. In the context of CITY, consequential play relates to the player's control over personal choices, being able to choose what to ask and say to other characters and what to click on. The following information as a result of their choice is part of this.

Real-life scenarios were also found to be one of the most popular learning objectives in CITY. Examples from the real world appear to create a more engaging learning environment than just receiving theory. This is especially evident in one of the lower secondary school girls' discussions of new locations. Even though they found their suggestion of a space station scenario to be a capturing new location, they settled for an airport after one argued that a journey to space would create an unrealistic sidetrack in the story. Previous findings state that real scenarios are more relatable, and the player will immerse herself in it and reflect on what it entails for her.

According to the players, the *conversations with the other characters* help raise their awareness to a more significant degree than other elements. This is an objective that is combined nicely with consequential play, where the player can get more options during their dialogue with essential figures.

8.3.2 Engagement Mechanics

Each 'Engagement Aspects' section in this chapter presents an overview of the participants' opinion of the most engaging elements in the game. Equivalent to the learning objectives, a table in chapter 3 (table 3.3) work to map the implemented elements to the elements found in the literature.

The players found *minigames* to be the most entertaining factor, especially the one encountered during the visit to the IT building. The primary focus of this minigame was on engaging the player and sustaining their motivation. It is therefore not surprising that they would regard this as the most exciting aspect of the game.

In relations to the learning objective *consequential play*, the players ranked seeing the *consequences of one's actions* as a central engagement driver. Those circumstances where they were allowed to determine the outcome of situations were assessed as having higher entertainment value than those without.

The light bulbs worked to motive some of the participants, while others forgot to look for them. In order to make them a focal part of the game, they should be given a more critical role. This could be done by adding a light bulb search quest to the street levels as well, ensuring that the players do not forget about them in between location visits.

8.3.3 Target Group

There was some divide between the various participating groups in regards to who the game is relevant to. Although all agreed that the game's main target group should be lower secondary school students, the game expert and the TGPA representative disagreed on the outer range of that scale. The game expert believed the game would work well in upper secondary school as well, while the recruitment expert and upper secondary school students suggested primary school rather than the older age groups. It would be intriguing to see how younger children respond to the concept of informative serious games, as research suggests to start recruitment for technology interest as early as possible (PwC, 2017). Nevertheless, this is not the main motivation for this study, hence beyond the extent of this research. It is, however, an intriguing question and could be part of future work.

8.3.4 Difficulty

The perceived difficulty of a game is central in the development of felt engagement. As described in Chapter 3, the gradual advancement of a game's complexity can motivate the player and induce a sense of flow. In the situation of CITY, the participants answered that they felt the game to be somewhat easy. At the same time, they remarked that the level of difficulty was not as important in this game as in others. Alternative engaging elements were pointed to that strived to assure the player's motivation. The minigames and the user's ability to decide who to talk to and what to say, was identified as the primary engagement elements.

Even though the level of challenge was deemed to hold a satisfactory position for the evaluators, research states that difficulty is one of the main factors when inducing entertainment. The participants were therefore encouraged to provide their suggestions to how to make it more difficult.

- Quiz
- More challenging dialogue choices
- Characters have different level of difficulty
- More minigames, preferably with learning aspects
- Levels based on age groups. Older students get more difficult questions and more comprehensible information

Nonetheless, the primary focus of the game is on providing information and increasing the player's awareness. If the player is unable to complete the game because of the increased difficulty, she might lose interest in understanding the information presented and even the concept of IT itself. One could argue that in order to avoid this scenario, the difficulty must be controlled.

Chapter 9

Discussion

This chapter discusses the relationships between the gathered data from the main data collection methods used in this thesis. It compares the findings from the initial prototype evaluation, the NKUL conference, and the final expert evaluation, drawing parallels to the related work discoveries from Chapter 3.

The prototype evaluation presents an original image of the game's starting point as a mere paper and digital storyboard. In the NKUL and final expert evaluation, the implemented game is tested and assessed. The NKUL results provide an overview of how the game is perceived by teachers and students, while the expert evaluation presents a deep dive into the game mechanics and a search to identify a reasoning behind the player's opinions.

Each evaluation chapter in this report (Chapter 4, 5, 7, 8) contains its own discussion section that reflects on the results and observations made in that described activity. As a result, this chapter will focus on comparing those results, allowing some to only be touched upon briefly as they are discussed to a great extent in their own chapters.

9.1 The Potential of Informative Serious Games

This thesis has explored the use of informative serious games as an alternative method of challenging the under-representation of females in IT. Previous research revealed that there exists limited opportunities for girls to be introduced to technology and programming, resulting in their decrease in interest in the topic. Consequently, this study seeks to investigate the use of an accessible web-based game to raise their awareness of what IT is and can be used for.

Results from the data collected revealed an interest in using games to promote information about technology and programming. Similar findings can be observed in the specialisation project, where participants were asked to share their thoughts on games aimed at awareness raising with information being the main learning element. Although initial experiments unveiled the concept to be attractive to many, further testing of a developed application remained. These results were obtained during the three main evaluation sessions and revealed a promising outcome. The first high-fidelity prototype was well received by the test subjects, both from the intended target group and from other players.

The participants' justification for their opinion of the game was grounded in the game's ability to provoke reflection in the player. They saw it as an invitation to confront previously known information in a new context. This enabled them to stop and think about what they were learning, thus regarding it differently. Nevertheless, it is important to point out that the evaluations sought to test the game's potential in improving knowledge of the subject presented, not to evaluate the player's new acquired understanding. Future assessments aimed at mapping the actual learning and awareness outcome, in contrast to the perceived change, remains and should be conducted.

9.2 Entertaining Elements and Learning Objectives

Engagement and awareness raising elements have been analysed and discussed in great lengths in Chapter 3, 5, and 8, and will therefore just be summaries in this section to avoiding repetition. Further details can be found in the mentioned chapters.

The results from the final evaluation with the target group and other experts are based on qualitative data gathered during interviews, both in groups and alone. By comparing these results with findings from previous iterations and the related work in Chapter 3, the learning objectives that work well in CITY can be identified.

Consequential play, *real-life scenarios*, and *conversations* with other characters were the most helpful mechanisms in raising awareness, resulting in these being the elements that work best in informative serious games. It is however, essential to note that these might not work the same way for other information games. CITY was made to examine and identify the best-suited

game elements based on the findings presented in table 3.3. Some features of the serious game might have been developed better than others.

9.2.1 Light Bulbs

The collectable item "light bulbs" received mixed feedback. Some players found them motivational because they would provide them with an advantage over the mayor in the final battle, while others forgot to search for them. It was stated by the participants of the prototype evaluation (Chapter 5) that the light bulbs needed to have a real function to be part of the game. Consequently, if their purpose in the game was not enough to convince the player to look for them, this would result in some discarding them as irrelevant. Another cause could be that they were only informed about the light bulbs' importance at the very beginning of the game, causing some to forget about them.

The players that did remember to look for the light bulbs thought they were motivating, and they spent time searching for them. This suggests that even though some players failed to recognise them, others benefited from seeking them out. The concepts of the light bulbs should therefore not be discarded but instead redesigned. One idea for making them more detectable to all players is to increase their visibility and use more efficient methods of prompting the player to look for them. One should encourage the player to try to find them throughout the game and emphasise their importance. This could make them a more engaging element the user could take advantage of.

9.3 Difficulty

The game's level of difficulty has been a central part of all the evaluations because of its fundamental role in generating engagement, as discussed in Chapter 3. The focus on difficulty comes from the theoretical nature of informative serious games, as these types of games might struggle to present information without being tedious. By creating a satisfactory challenging environment, the player might enjoy the information and the game more.

Although the game was seen as somewhat easy to players, they stated that the level of difficulty in CITY was not as important as in other games. The game expert in the last evaluation explained that this was because of how

the game focuses on the narrative and how the other game elements are tied together with that. She declared that it is more important that the game has the power to make the students reflect on the information conveyed, than to have them struggle to complete the game. This would only lead to frustration and even some players quitting the game.

When this is said, it could be beneficial to investigate further how to increase the sense of difficulty in CITY, for instance, to accommodate an older audience. It was suggested by the participants to divide the game into class-levels, one for lower and one for upper secondary school. This would make the game more attractive to a broader range of students. Additionally, for the older students, the information presented could be at a more advanced level than that of the younger, with more challenging language and more difficult choices to be made in the battle against the mayor. This would work to increase the experienced difficulty level.

Nevertheless, it is essential to keep in mind that an awareness raising game must be playable by everyone. Further investigations into the target group's appropriate level of difficulty should therefore be conducted.

9.4 Target Group

Table 9.1 provides an overview of what the participants from the evaluations thought were the most appropriate target group for the informative serious game CITY. All respondents agree to some extent that the game is suitable for lower secondary school, but some also included a lower or higher age group. The reasons for this gap is perhaps the game's perceived level of difficulty. As described in section 9.3, the challenge level was experienced as a bit easy by some, which can have led them to believe that the game is more fitting for primary school students.

An additional cause could be in relations to the graphics and how the information was formulated. The theory was on purpose expressed straightforwardly to accommodate various levels of reading skills and aimed at being understandable to all lower secondary school students.

An interesting thing to notice is the gap between the teachers and students, both from NTNU and secondary school. The teachers considered the game

Participants	**Perceived Target Group**
Teachers	Lower and Upper Secondary School
Students	Lower Secondary School
Lower Secondary School	Lower Secondary School
Upper Secondary School	Primary and Lower Secondary School
Game Expert	Lower and Upper Secondary School
TGPA Representative	Primary and Lower Secondary School

TABLE 9.1: An overview of what the participants from the evaluations thought were the most appropriate target group

to be more appropriate to the higher grades, thus including the upper secondary school students. However, the students choose to allocate the game in the lower age groups. In Chapter 7 it was discussed whether this was a result of the teachers' experience with secondary school students or the students' being closer to the target group in age. After evaluating the game with both lower and upper secondary school students, it became clear that both thought the game to be most suitable to lower secondary school and even primary school. Future work could therefore benefit from investigating ways to adjust the game to fit more age groups and explore the possibility of using it in primary schools.

Chapter 10

Conclusion

10.1 Summary of Results

This study contributes to the understanding of the female under-representation in IT and investigates an alternative method of raising their awareness and interest of the subject. The main contributions to the area of informative serious games for increasing awareness of IT are made present in: a state of the arts section (Chapter 3), the implementation of the game (Chapter 6), and the evaluation and results of the game CITY (Chapter 4, 5, 7, 8).

Previous findings revealed a gap in today's literature on serious games that utilise information as its primary method for raising awareness. As a result, this research focuses on making that gap smaller by identifying the best-suited game elements to use in these types of games and how it is received by potential players. A conceptual prototype was therefore designed and evaluated to explore the possibility of using informative serious games to raise awareness.

10.2 Research Questions

This section presents an answer to the research questions that have laid the foundation for this thesis.

> **RQ1:** How can an informative serious game be designed to raise girls' awareness of IT?

This study seeks to demonstrate how serious games can be designed to make information about IT available to girls in the hope of increasing their interest

in it. The answer to the main research question rests on the findings of its sub-questions and is comprised of the knowledge found throughout the chapters. The design, implementation, and evaluation of the informative serious game CITY are described in detail in this thesis and exhibits a result that establishes the value of such a game.

Table 3.3 in section 3.5 provides a set of both engagement elements and learning objectives that can be used when designing serious games for raising girls' and others' awareness in general. These were implemented and evaluated by the participating test subjects. Interesting findings from the NKUL conference evaluation revealed that all the participants thought the game to have the ability to increase the player's awareness. CITY is aimed at raising awareness about technology and programming to girls and aspire to be a tool to minimise the existing gender gap. The findings in this thesis suggest that the concept of informative serious games are well-suited to raise awareness of other topics as well and to both genders.

> **RQ1.1:** How can engagement elements be used to raise awareness of IT when designing the informative serious game?

In the chapter on related work (Chapter 3), an investigation into which types of game elements are most beneficial to use when designing an informative serious game was conducted. Because of the limited literature on information games, a broader search was conducted, which included serious games and games for raising awareness. The findings from this exploration laid the foundation for CITY.

The results demonstrate the importance of a coherent story tightly coupled with the game's learning objectives. In CITY the storyline revolves around an ignorant mayor who has decided to ban technology, causing the player to lay out on a quest to gain enough knowledge to convince him otherwise. The story motivates the player to explore the world in search of new information that can be used in the final battle against the mayor.

Consequential play was also evaluated by the test subjects to be one of the primary drivers of engagement in the game. It led to a feeling of empowerment and a curiosity to learn what the consequence of that action would be. Allowing the player to feel like they are in charge of shaping the story facilitates a sense of achievement. Minigames were another well-received engaging game element, which was unsurprising as this game mechanic was added to the game with the purpose of being entertaining. The use of

minigames in informative serious games work well to maintain the user's interest in the overall goal and to provide a variation from the information presented.

> **RQ1.2:** How can learning elements be used to raise awareness when designing the informative serious game?

Similar to the exploration conducted on engagement elements, potential learning objectives to raise awareness and increase knowledge was identified in Chapter 3. The review revealed that serious games rely on narrative storytelling both to raise engagement and to induce learning outcome. Research by Ravyse et al. (2016) suggests that it is the use of narrative storytelling linked with learning material that provides a successful outcome of a serious game. The player can use this narrative theme as a cognitive organiser of materials perceived while playing, which works to boost the learning effects (M. Adams et al., 2012; Berger and Sæthre, 2018).

The most central learning element was found to be information itself. Results showed that the participants thought that information presented in a clear and understandable way was the most useful method of learning while playing the game. The use of realistic and relatable scenarios was also considered favourable. Furthermore, merging the available theory with the option of selecting whom to talk to and what to ask, namely the element of consequential play, proved to be a powerful combination and deemed the most effective by the test subjects.

10.3 Strengths and Limitations

The findings of this thesis are based on a triangulation of data from several methods of collecting evidence. The prototype evaluation sought to gather qualitative data from experts to ensure a high standard of the concept. The evaluation was conducted using interviews and observations. During the NKUL conference, the focus was on assessing the potential of the designed informative serious game CITY seen from a teacher's perspective. This phase utilised a quantitative data generating method through a questionnaire. Lastly, the main evaluation with experts and the target group was conducted using interviews and observations to gain insight into how the game worked to raise awareness of IT. The triangulation of the data gathered

from the qualitative and quantitative sources helped improve the validity of the results presented.

One limitation of the research is the number of teachers that chose to participate in the NKUL evaluation. Because of their limited interest in participating in the test, NTNU students had to be asked to partake. The end results were 50/50 teachers and students. The questionnaire was, however, made to accommodate this and included the option of stating which group you belonged to.

A second limitation rests on the game's nature of being a conceptual prototype. Because the purpose of the game is to investigate the potential of an informative serious game, no formal usability test has been conducted. To test the game's functionality has never been the intention of this research, but rather to explore the idea of using information as the primary game mechanic. In the main expert evaluation described in Chapter 8, all participants were informed of common misconceptions in the game. However, the NKUL evaluators were not as the game was still in an early stage of production and testing. This might have influenced their overall impression of the game.

Lastly, it is difficult to measure the real effects of change induced by a game. The assessment of the game seeks to answer if an informative game can be used to raise awareness, and the research methods try to the extent possible to find evidence of this development. Nevertheless, the data collected can only provide insight into what the participants have reported, thus relying on their perceived increase in interest and conscious transformation.

10.3.1 Discussion of Data Collecting Methods

The data collection was accomplished through several selected methods; interviews, group discussions, questionnaire, and observations.

Interviews

The interviews were held immediately after the gameplay for both the prototype and the main assessment. This was done to ensure that their impressions and thoughts were fresh in mind. Although the interview method facilitates a safe environment for sharing thoughts and opinions, being interviewed by the developer of the artefact in question might result in the

participants feeling the need to withhold negative information. The interviewees were therefore encouraged to give their true judgement to ensure this would not happen.

In hindsight, it would have been beneficial to record the interviews to ensure that all aspects of the conversation were captured and remembered. As previously stated, this was not done in order to guarantee the participants' anonymity and to reduce the time used to transcribe and code the results. Additionally, it would have been profitable to have made further investigations into the test subjects' impression of the game mechanics to learn why the elements not mentioned as engaging and awareness raising was seen as less appealing than the once they identified.

Group Discussions

A group interview was held as part of the first concept evaluation to gain insight into the game idea and the concept. This method could have been improved by recruiting an external participant to take notes, as it became clear during the conversation that the participants had a lot on their mind. As a result, it became difficult to take notes and facilitate the discussion at the same time. Furthermore, during the conversation, the researcher could have been more stern when controlling the word to ensuring that every participant's opinion was heard. This was at times challenging because of the dominating behaviour of some of the interviewees.

Questionnaire

The questionnaire was a suitable tool for collecting data from a large number of respondents. A common challenge when using questionnaires is the inability to prohibit misinterpretations or difficulties the respondent might have while completing it. This was not the case in this execution, as the researcher was nearby to answer any arising questions. However, there is the risk that such disruptions might lead to the participant being influenced by the researcher's way of seeing things. With this in mind, whenever a question about the form was asked, the researcher would clarify the misconception and let the respondent continue.

The questionnaire had been distributed after the participants finished the game while playing at the NKUL conference. Because of the busy nature

of people partaking in such events, the questionnaire was designed to be short and easy to fill out. It would, however, have been desirable to include additional questions, investigating the specific game mechanics and learning objectives further to analyse a boarder opinion on them.

Observations

Observations provided useful data about the participants' actions that could be compared with what they said in the questionnaire or interviews. Bias is a common obstacle when collecting data based on observations. This comes from the selective nature of memory and the way humans sometimes perceive what they want to perceive (Oates, 2006). Notes were always taken as not to rely on subjective memory, seeking to substantiate and increase the strength of the data collected during observations. The data was also triangulated against the interviews and questionnaire results to increase its soundness.

10.4 Recommendations for Future Work

Future work following this thesis should focus on several things. Firstly, the results of this thesis conclude that the concept prototype CITY can be used to increase a player's awareness of IT. Further evaluations aimed at uncovering weaknesses and functionality issues should be administrated to ensure and strengthen the game's usability. By removing problems related to the interface, the user's experience of the game could be enhanced, as well as the potential learning outcome. It also makes it more accommodating to seasoned players since their previous experience might lead them to discard the game if it does not live up to their expectations.

Consequently, the second recommendation is to analyse and catalogue the proposed changes from the main evaluation to expose their value and potential in the game. These identified elements are usability issues the players' found during the assessment, and by addressing them, CITY could be made more user-friendly. It would also be an intriguing idea to explore the use of an end page with recommended resources for interested players. This would encourage users that found the presented information fascinating, to continue learning more about it and perhaps become more curious about IT.

Thirdly, the game could benefit from conducting further investigation of which locations to use in the game. As of today, the game relies on a hospital and an IT business to demonstrate technology and programming to the players. An in-depth analysis of other locations could reveal which are the most interesting to girls and which contributes to the highest degree of increased awareness.

The results in this thesis are based on what the participants say and do in contrast to what they actually know and believe. Further investigations into what they in reality learn from playing the game should be performed to strengthen the results presented in this research. By evaluating what they know before and after the gameplay, evidence of their knowledge and awareness could be discovered and analysed. Similar examinations of whether the game has a real effect on the player's motivation to learn more about IT should also be investigated further.

Bibliography

Adya, M. and Kaiser, K. M. (2005). "Early determinants of women in the IT workforce: a model of girls' career choices". In: *Information Technology People* 18.3, 230–259. ISSN: 0959-3845. URL: http://www.emeraldinsight.com/doi/10.1108/09593840510615860.

Ali, A. et al. (2017). "Raising Awareness on Hydroponics via an Educational Video Game Using an Indirect Teaching Method". In: *2017 9th IEEE-GCC Conference and Exhibition (GCCCE)*, 1–6. URL: https://www.researchgate.net/publication/327323879_Raising_Awareness_on_Hydroponics_via_an_Educational_Video_Game_Using_an_Indirect_Teaching_Method.

Alserri, S. A., Zin, N. A. M., and Wook, T. S. M. T. (2017). "Gender-based engagement model for designing serious games". In: *2017 6th International Conference on Electrical Engineering and Informatics (ICEEI)*, 1–5. URL: https://ieeexplore.ieee.org/document/8312443.

Amazon Web Services. URL: https://aws.amazon.com/.

Ashcraft, C. et al. (2012). *Girls in IT: The Facts Infographic*. URL: https://www.ncwit.org/sites/default/files/resources/girlsinit_report2012_final.pdf.

Babel. URL: https://babeljs.io/.

Bach, D. (2016). *Study examines why some STEM fields have fewer women than others*. URL: https://phys.org/news/2016-10-stem-fields-women.html.

Bandura, A. (1977). "Self-Efficacy: Toward a Unifying Theory of Behavioral Change". In: *Psychological Review* 84, pp. 191–215. URL: https://psycnet.apa.org/record/1977-25733-001.

Baranowski, T. et al. (2008). "Playing for Real: Video Games and Stories for Health-Related Behavior Change". In: *American Journal of Preventive Medicine* 34.1, 74 –82.e10. ISSN: 0749-3797. URL: http://www.sciencedirect.com/science/article/pii/S0749379707006472.

Baranyi, R. et al. (2017). "NutritionRush - a serious game to support people with the awareness of their nutrition intake". In: *2017 IEEE 5th International Conference on Serious Games and Applications for Health (SeGAH)*. IEEE, 1–8.

ISBN: 978-1-5090-5482-4. URL: http://ieeexplore.ieee.org/document/7939271/.

Barr, M. (2017). "Video games can develop graduate skills in higher education students: A randomised trial". In: *Computers Education* 113. URL: https://www.researchgate.net/publication/317242654_Video_games_can_develop_graduate_skills_in_higher_education_students_A_randomised_trial.

Beede, D. N. et al. (2011). "Women in STEM: A Gender Gap to Innovation". In: *SSRN Electronic Journal*. ISSN: 1556-5068. URL: http://www.ssrn.com/abstract=1964782.

Berg, M. van den (2016). *Beating anxiety and boredom: serious game design lessons*. URL: https://www.mcvandenberg.com/blog/beating-anxiety-and-boredom-serious-game-design-lessons/.

Berger, E. and Sæthre, T. H. (2018). "PrivaCity: A Chatbot Serious Game to Raise the Privacy Awareness of Teenagers". In:

Berger, E. et al. (2017). "Supporting the co-design of games for privacy awareness". In: *Proceedings of 21th International Conference on Interactive Collaborative Learning, Springer (in press)*.

Boller, S. (2014). *How Much Story Does a Serious Game Need?* URL: http://www.theknowledgeguru.com/much-story-serious-game-need/.

Bourgonjon, J. et al. (2011). "Parental acceptance of digital game-based learning". In: *Computers Education* 57.1, 1434–1444. ISSN: 03601315. URL: https://linkinghub.elsevier.com/retrieve/pii/S036013151100008X.

Boyle, E.A. et al. (2016). "An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games". In: *Computers and Education* 94, 178–192. ISSN: 03601315. URL: https://linkinghub.elsevier.com/retrieve/pii/S0360131515300750.

Bryce, J. and Rutter, J. (2002). "Killing Like a Girl: Gendered Gaming and Girl Gamers' Visibility". In: URL: http://www.digra.org/wp-content/uploads/digital-library/05164.00312.pdf.

Cai, H. et al. (2016). "Male = Science, Female = Humanities: Both Implicit and Explicit Gender-Science Stereotypes Are Heritable". In: 7, 412–419. ISSN: 1948-5506, 1948-5514. URL: http://journals.sagepub.com/doi/10.1177/1948550615627367.

Calderón, A. and Ruiz, M. (2015). "A systematic literature review on serious games evaluation: An application to software project management". In: *Computers and Education* 87, 396–422. ISSN: 0360-1315. URL: http://www.sciencedirect.com/science/article/pii/S0360131515300166.

Cassell, J. and Jenkins, H. (1998). *Chess For Girls?* URL: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.207.7635&rep=rep1&type=pdf.

Castell, S. de and Bryson, M. (1998). "Retooling play: dystopia, dysphoria, and difference". In: pp. 232–261.

Catalyst (2013). *Why Diversity Matters*. URL: https://www.catalyst.org/system/files/why_diversity_matters_catalyst_0.pdf.

Chen, J. (2007). "Flow in games (and everything else)". In: *Communications of the ACM* 50.4, p. 31. ISSN: 00010782. URL: https://dl.acm.org/citation.cfm?doid=1232743.1232769.

Cherry, K. (2018). *Extrinsic vs. Intrinsic Motivation: What's the Difference?* URL: https://www.verywellmind.com/differences-between-extrinsic-and-intrinsic-motivation-2795384.

Cheryan, S. et al. (2017). "Why are some STEM fields more gender balanced than others?" In: *Psychological Bulletin* 143(1), pp. 1–35. URL: http://dx.doi.org/10.1037/bul0000052.

Chess, S., Evans, N., and Baines, J. J. (2016). "What Does a Gamer Look Like? Video Games, Advertising, and Diversity". In: *Television and New Media* 18. URL: https://www.researchgate.net/publication/301357470_What_Does_a_Gamer_Look_Like_Video_Games_Advertising_and_Diversity.

Chisholm, J. (n.d.). *What is co-design?* URL: http://designforeurope.eu/what-co-design.

Clark, D., Tanner-Smith, E., and Killingsworth, S. (2015). "Digital Games, Design, and Learning: A Systematic Review and Meta-Analysis". In: *Review of Educational Research* 86. URL: https://www.researchgate.net/publication/277630332_Digital_Games_Design_and_Learning_A_Systematic_Review_and_Meta-Analysis.

Cohen, D. and Crabtree, B. (2006). *Qualitative Research Guidelines Project*. URL: http://www.qualres.org/HomeSemi-3629.html.

Corbett, C. (2015). *Solving the equation: the variables for women's success in engineering and computing*. AAUW. ISBN: 978-1-879922-45-7.

Correll, S. J. (2001). "Gender and the Career Choice Process: The Role of Biased Self-Assessments". In: *American Journal of Sociology* 106, pp. 1691–1730. URL: https://www.journals.uchicago.edu/doi/full/10.1086/321299.

– (2004). "Constraints into Preferences: Gender, Status, and Emerging Career Aspirations". In: *American Sociological Review* 69.1, pp. 93–113. URL: https://journals.sagepub.com/doi/10.1177/000312240406900106.

Corti, K. (2006). *Game-Based Learning: A Serious Business Application*. URL: https://www.cs.auckland.ac.nz/courses/compsci777s2c/lectures/Ian/serious%20games%20business%20applications.pdf.

Cosma, G. et al. (2016). "PROCEE: a PROstate Cancer Evaluation and Education serious game for African Caribbean men". In: *Journal of Assistive Technologies* 10.4, 199–210. ISSN: 1754-9450. URL: https://www.researchgate.net/publication/311714549_PROCEE_a_PROstate_Cancer_Evaluation_and_Education_serious_game_for_African_Caribbean_men.

Costabile, M. et al. (2003). "Evaluating the educational impact of a tutoring hypermedia for children". In: *Information Technology in Childhood Education Annual* 15.

Csikszentmihalyi, M. (1975). *Beyond boredom and anxiety*. Jossey-Bass Publishers.

– (1990). *Flow: The Psychology of Optimal Experience*.

DAMVAD (2014). *Dimensjonering av avansert IKT-kompetanse*. URL: https://www.regjeringen.no/globalassets/upload/kmd/aif/dokumenter/dimensjonering_avansert_ikt_kompetanse.pdf?id=2260119.

Dele-Ajayi, O. et al. (2018). "Designing for All: Exploring Gender Diversity and Engagement with Digital Educational Games by Young People." In: *2018 IEEE Frontiers in Education Conference (FIE)*, 1–9. URL: https://ieeexplore.ieee.org/document/8658553.

Dickey, M. D. (2006). "Girl gamers: the controversy of girl games and the relevance of female-oriented game design for instructional design". In: *British Journal of Educational Technology* 37.5, 785–793. ISSN: 1467-8535. URL: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1467-8535.2006.00561.x.

Dubach, I. (2018). *Patterns in STEM grades of girls versus boys*. URL: https://www.sciencedaily.com/releases/2018/09/180925115244.htm.

Dweck, C. S. (2007). "Is Math a Gift? Beliefs That Put Females at Risk." In: *Why aren't more women in science?: Top researchers debate the evidence.* American Psychological Association, 47–55. ISBN: 1-59147-485-X. URL: https://psycnet.apa.org/record/2006-22337-004.

D'Apice, C. et al. (2015). "DMS2015short-2: Advanced learning technologies for eLearning in the enterprise: Design of an Educational Adventure Game to teach computer security". In: *Journal of Visual Languages Computing* 31, pp. 260 –266. ISSN: 1045-926X. URL: https://www.sciencedirect.com/science/article/pii/S1045926X15000610?via%3Dihub.

EIGE (2013). "European Institute for Gender Equality - 2013 - Awareness raising study on 'Collection of methods'". In: URL: https://eige.europa.eu/sites/default/files/documents/EIGE-DOMESTIC-VIOLENCE-AWARENESS-RAISING.pdf.

Ertesvåg, O. R. and Leine, H. L. (2019). *NRKs rektorundersøkelse: Fire av fem skoler har mobilforbud*. URL: https://www.nrk.no/norge/nrks-rektorundersokelse_-fire-av-fem-skoler-har-mobilforbud-1.14291388.

Ertl, B., Luttenberger, S., and Paechter, M. (2017). "The Impact of Gender Stereotypes on the Self-Concept of Female Students in STEM Subjects with an Under-Representation of Females". In: *Frontiers in Psychology* 8. ISSN: 1664-1078. URL: https://www.frontiersin.org/articles/10.3389/fpsyg.2017.00703/full.

ESA (2018). *Essential Facts About the Computer and Video Game Industry*. URL: http://www.theesa.com/wp-content/uploads/2018/05/EF2018_FINAL.pdf.

Facts on the Nobel Prize in Chemistry. URL: https://www.nobelprize.org/prizes/facts/facts-on-the-nobel-prize-in-chemistry.

Facts on the Nobel Prize in Physics. URL: https://www.nobelprize.org/prizes/facts/facts-on-the-nobel-prize-in-physics.

Facts on the Nobel Prize in Physiology or Medicine. URL: https://www.nobelprize.org/prizes/facts/facts-on-the-nobel-prize-in-physiology-or-medicine.

Firebase. URL: https://firebase.google.com/.

Fontana, A. and Frey, J. H. (1994). "Interviewing: The art of science". In: pp. 361–376.

Fox, J. and Tang, W. Y. (2016). "Women's experiences with general and sexual harassment in online video games: Rumination, organizational responsiveness, withdrawal, and coping strategies". In: *New Media Society* 19. URL: https://journals.sagepub.com/doi/full/10.1177/1461444816635778.

Gailey, C. W. (1993). "Mediated Messages: Gender, Class, and Cosmos in Home Video Games". In: URL: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.0022-3840.1993.845217931.x.

GameMaker Studio 2. URL: https://www.yoyogames.com/gamemaker.

GDevelop. URL: https://gdevelop-app.com/.

Gee, J. (2003). "What Video Games Have to Teach Us About Learning and Literacy". In: *Computers in Entertainment* 1, p. 20. URL: https://www.researchgate.net/publication/220686314_What_Video_Games_Have_to_Teach_Us_About_Learning_and_Literacy.

Gee, J. (2007). "What Video Games Have to Teach Us About Learning and Literacy". In: *Cyberpsychology Behavior* 12.

Girard, C., Ecalle, J., and Magnan, A. (2013). "Serious games as new educational tools: How effective are they? A meta-analysis of recent studies". In: *Journal of Computer Assisted Learning* 29. URL: https://onlinelibrary.wiley.com/doi/full/10.1111/j.1365-2729.2012.00489.x.

Girls in STEM, (2017). URL: https://www.accenture.com/t20170905T101544Z__w__/ie-en/_acnmedia/PDF-60/Accenture-Girls-in-STEM-Research-Report-2017-online.pdf.

Girls in Tech. URL: https://girlsintech.org/.

Girls Who Code. URL: https://girlswhocode.com/.

Gjersoe, N. (2018). "Bridging the gender gap: why do so few girls study Stem subjects?" In: *The Guardian*. URL: https://www.theguardian.com/science/head-quarters/2018/mar/08/bridging-the-gender-gap-why-do-so-few-girls-study-stem-subjects.

Guillén-Nieto, V. and Alesón-Carbonell, M. (2012). "Serious games and learning effectiveness: The case of It's a Deal!" In: *Computers Education* 58, pp. 435–448. URL: https://www.researchgate.net/publication/220140688_Serious_games_and_learning_effectiveness_The_case_of_It's_a_Deal.

Hall, T. (2017). *When to Do an Expert Evaluation, and How to Make It Stick*. URL: https://uxplanet.org/when-to-do-an-expert-evaluation-and-how-to-make-it-stick-8e53fc34682f.

Hartmann, T., Moller, I., and Krause, C. (2014). "Factors underlying male and female use of violent video games". In: *New Media Society* 17. URL: https://journals.sagepub.com/doi/full/10.1177/1461444814533067.

Heroku Dev Center. URL: https://devcenter.heroku.com/.

Hevner, A. R. (2007). "A Three Cycle View of Design Science Research". In: 19, p. 7. URL: https://www.uio.no/studier/emner/jus/afin/FINF4002/v13/hefner-design.pdf.

Hevner, A. R. et al. (2004). "Design Science in Information Systems Research". In: *Management Information Systems Quarterly* 28 (1).

Hill, C., Corbett, C., and St. Rose, A. (2010). *Why so few? women in science, technology, engineering, and mathematics*. AAUW. ISBN: 978-1-879922-40-2.

Jans, S. D. et al. (2017). "Using games to raise awareness: How to co-design serious mini-games?" In: *Computers Education* 110, pp. 77 –87. ISSN: 0360-1315. URL: https://doi.org/10.1016/j.compedu.2017.03.009.

Jenter Koder. URL: http://www.jenterkoder.no/.

Jiang, J. (2018). *Millennials stand out for their technology use*. URL: https://www.pewresearch.org/fact-tank/2018/05/02/millennials-stand-out-for-their-technology-use-but-older-generations-also-embrace-digital-life/.

Kafai, Y. V. (1998). "From Barbie to Mortal Kombat". In: ed. by Justine Cassell and Henry Jenkins. Cambridge, MA, USA: MIT Press. Chap. Video Game Designs by Girls and Boys: Variability and Consistency of Gender Differences, pp. 90–114. ISBN: 0-262-03258-9. URL: http://dl.acm.org/citation.cfm?id=295056.295063.

Kahn, S. and Ginther, D. (2017). *Women and stem. Technical report*. URL: https://www.nber.org/papers/w23525.pdf.

Kampa, A., Haake, S., and Burelli, P. (2016). "Storytelling in Serious Games". In: vol. 9970, pp. 521–539. URL: https://link.springer.com/chapter/10.1007/978-3-319-46152-6_19.

Kerkhoven, A. H. et al. (2016). "Gender Stereotypes in Science Education Resources: A Visual Content Analysis". In: *PLOS ONE* 11.11, pp. 1–13. URL: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0165037.

Kiili, K. et al. (2014). "Flow Experience as a Quality Measure in Evaluating Physically Activating Collaborative Serious Games". In: *International Journal of Serious Games* 1. URL: http://journal.seriousgamessociety.org/index.php/IJSG/article/view/23.

Kowert, R., Breuer, J., and Quandt, T. (2017). "Women are from FarmVille, Men are from ViceCity: The cycle of exclusion and sexism in video game content and culture". In: pp. 136–150. ISBN: 978-1-138-64363-5. URL: https://www.researchgate.net/publication/315810241_Women_are_from_FarmVille_Men_are_from_ViceCity_The_cycle_of_exclusion_and_sexism_in_video_game_content_and_culture.

Labaree, R. V. (2018). *Research Guides: Organizing Your Social Sciences Research Paper: 5. The Literature Review*. URL: https://libguides.usc.edu/writingguide/literaturereview.

Lacey, T.A. and Wright, B. (2009). "Occupational employment projections to 2018". In: *Monthly Labor Review*.

Lent, R. W., Brown, S. D., and Larkin, K. C. (1986). "Self-efficacy in the prediction of academic performance and perceived career options". In: *Journal of Counseling Psychology* 33.3, 265–269. URL: https://pdfs.semanticscholar.org/5f8a/10debdd24a119107862c2f06dd67d31fd3fd.pdf.

Luz, S. et al. (2014). "Designing a serious game for community-based disease prevention in the Amazon". In: *Proceedings of the 11th Conference on Advances in Computer Entertainment Technology Article No. 41*. URL: https://dl.acm.org/citation.cfm?doid=2663806.2663857.

Lær Kidsa Koding. URL: https://kidsakoder.no/.

M. Adams, D. et al. (2012). "Narrative Games for Learning: Testing the Discovery and Narrative Hypotheses". In: *Journal of Educational Psychology* 104, pp. 235–249. URL: https://psycnet.apa.org/fulltext/2011-21774-001.html.

Marcotte, A. (2015). *Teen girls play video games, but they minimize their contact with other players. Boys, on the other hand, use games to socialize*. URL: http://www.slate.com/blogs/xx_factor/2015/08/18/teen_girls_play_video_games_but_they_minimize_their_contact_with_other_players.

Master, A., Cheryan, S., and Meltzoff, A. N. (2016). "Computing whether she belongs: Stereotypes undermine girls' interest and sense of belonging in computer science". In: *Journal of Educational Psychology* 108.3, pp. 424–437. ISSN: 0959-3845. URL: http://www.emeraldinsight.com/doi/10.1108/09593840510615860.

Mayer, R. E. (1983). *Thinking, Problem Solving, Cognition*. Series of books in psychology. Freeman, W. H. ISBN: 978-0-7167-1440-8. URL: https://books.google.no/books?id=z_eHQgAACAAJ.

McGloin, R., Farrar, F., and Fishlock, J. (2015). "Triple Whammy! Violent Games and Violent Controllers: Investigating the Use of Realistic Gun Controllers on Perceptions of Realism, Immersion, and Outcome Aggression". In: *Journal of Communication* 65. URL: https://www.researchgate.net/publication/272890554_Triple_Whammy_Violent_Games_and_Violent_Controllers_Investigating_the_Use_of_Realistic_Gun_Controllers_on_Perceptions_of_Realism_Immersion_and_Outcome_Aggression.

Methods for expert evaluation. URL: https://www.allaboutux.org/expert-methods.

Miltenburg, C. V. (2014). *Games for Good - Research into the use of serious games to raise awareness for charitable organizations*. URL: http://arno.uvt.nl/show.cgi?fid=134760.

Morschheuser, B., Maedche, A., and Walter, D. (2017). "Designing Cooperative Gamification: Conceptualization and Prototypical Implementation". In: URL: https://dl.acm.org/citation.cfm?doid=2998181.2998272.

Mortara, M. et al. (2014). "Learning cultural heritage by serious games". In: *Journal of Cultural Heritage* 15.3, 318–325. ISSN: 12962074. URL: https://linkinghub.elsevier.com/retrieve/pii/S1296207413001349.

Mortensen, D. (2019). *How to Do a Thematic Analysis of User Interviews*. URL: https://www.interaction-design.org/literature/article/how-to-do-a-thematic-analysis-of-user-interviews.

Moss-Racusin, C. A. et al. (2018). "Reducing STEM gender bias with VIDS (video interventions for diversity in STEM)". In: *Journal of Experimental Psychology: Applied*. URL: http://dx.doi.org/10.1037/xap0000144.

Mouaheb, H. et al. (2012). "The Serious Game: What Educational Benefits?" In: *Procedia - Social and Behavioral Sciences* 46, 5502–5508. ISSN: 18770428. URL: https://linkinghub.elsevier.com/retrieve/pii/S187704281202201X.

Nobel Prize awarded women. URL: https://www.nobelprize.org/prizes/lists/nobel-prize-awarded-women.

Oates, B. J. (2006). *Researching Information Systems and Computing*. SAGE Publications. ISBN: 9781412902243.

Paaßen, B., Morgenroth, T., and Stratemeyer, M. (2016). "What is a True Gamer? The Male Gamer Stereotype and the Marginalization of Women in Video Game Culture". In: *Sex Roles*, pp. 1–15. URL: https://www.researchgate.net/publication/307976764_What_is_a_True_Gamer_The_Male_Gamer_Stereotype_and_the_Marginalization_of_Women_in_Video_Game_Culture.

Pajares, F. (2005). "Self-Efficacy During Childhood and Adolescence - Implications for Teachers and Parents". In:

Paliokas, I., Kekkeris, G., and Georgiadou, K. (2008). "Study of Users' Behaviour in Virtual Reality Environments". In: *The International Journal of Technology, Knowledge and Society* 4, pp. 121–132. URL: https://www.researchgate.net/publication/200025421_Study_of_Users'_Behaviour_in_Virtual_Reality_Environments.

Pange, J., Lekka, A., and Katsigianni, S. (2018). "Serious Games and Motivation". In: *Interactive Mobile Communication Technologies and Learning*. Ed. by M. E. Auer and T. Tsiatsos. Vol. 725. Springer International Publishing, 240–246. ISBN: 978-3-319-75174-0. URL: https://www.researchgate.net/publication/323157657_Serious_Games_and_Motivation.

Parker, C. (2018). *A meta-analysis of the cognitive and motivational effects of serious games*. URL: http://theinstitute.ieee.org/ieee-roundup/blogs/blog/how-to-get-more-girls-interested-in-stem-fields.

Petersen, K. (2018). URL: https://trilateralresearch.co.uk/collaborative-innovation-the-advantages-of-co-design-in-creating-sustainable-technological-solutions/.

Phaser. URL: https://phaser.io/.

Phaser - HTML5 Game Framework. URL: https://photonstorm.github.io/phaser3-docs/index.html.

Phaser Alternatives and Reviews. URL: https://alternative.me/phaser.

Plechawska-Wojcik, M. and Robaczewska, J. (2015). "A Serious Game Raising Awareness and Experience of Depression". In:

PwC (2017). *Women in Tech - Time to close the gender gap*. URL: https://www.pwc.co.uk/women-in-technology/women-in-tech-report.pdf.

Ravyse, W. et al. (2016). "Success factors for serious games to enhance learning: a systematic review". In: *Virtual Reality*. URL: https://link.springer.com/article/10.1007/s10055-016-0298-4.

Rebolledo-Mendez, G. et al. (2009). "Societal Impact of a Serious Game on Raising Public Awareness: The Case of FloodSim". In: *Proceedings of the 2009 ACM SIGGRAPH Symposium on Video Games*. ACM, 15–22. ISBN: 978-1-60558-514-7. URL: http://doi.acm.org/10.1145/1581073.1581076.

Romrell, D. (2013). "Gender and Gaming: A Literature Review". In: *36th Annual Proceedings: Selected research and development papers presented at the Annual Convention of the AECT*, pp. 170–182.

Rubin, A. et al. (1997). "What Kind of Educational Computer Games Would Girls Like?" In:

Samuelsson, M. and Samuelsson, J. (2016). "Gender differences in boys' and girls' perception of teaching and learning mathematics". In: *Open Review of Educational Research* 3.1, pp. 18–34. URL: https://www.tandfonline.com/doi/full/10.1080/23265507.2015.1127770.

Saxegaard, E. (2018). "Informative Serious Games to Increase Girls' Awareness of IT". In: p. 88.

Sayers, R. (2006). *Principles of Awareness Raising for Information Literacy,a case study*. URL: https://unesdoc.unesco.org/ark:/48223/pf0000147637/PDF/147637eng.pdf.multi.

Serussi, S. (2017). "Girls and programming in lower secondary schools: a Norwegian case". In: p. 96.

– (2018). "Increasing IT Interest Among Girls in Secondary School: Lectures and Workshops". In: p. 127.

Shodhan, S. (2017). *Intrinsic vs Extrinsic Motivation in Games*. URL: https://medium.com/@SharanShodhan/intrinsic-and-extrinsic-motivation-in-games-a8bbc06aac4.

Spangenberger, P. et al. (2018). "Can a Serious Game Attract Girls to Technology Professions?" In: *Science and Technology*, p. 12.

Staiger, C. (n.d.). *Women in IT: Why is the technology sector dominated by men?* URL: https://www.tig.co.uk/blogs/women-technology-sector-dominated-men/.

Stege, L., Lankveld, G. van, and Spronck, P. (2011). "Serious Games in Education". In:

Suellentrop, C. (2018). "Super Mario Run's Not-So-Super Gender Politics". In: *The New York Times*. ISSN: 0362-4331. URL: https://www.nytimes.com/2016/12/22/opinion/super-mario-runs-not-so-super-gender-politics.html.

The Consequences of Excluding Women in Science, (2016). URL: https://www.latrobe.edu.au/nest/the-consequences-of-excluding-women-in-science/.

The Top 10 Video Game Engines (2019). URL: https://www.gamedesigning.org/career/video-game-engines/.

Unity. URL: https://unity.com/.

Unity vs Phaser.io. URL: https://www.slant.co/versus/1047/1065/~unity_vs_phaser-io.

Usability.gov (2013). *Heuristic Evaluations and Expert Reviews*. URL: https://www.usability.gov/how-to-and-tools/methods/heuristic-evaluation.html.

Vaishnavi, V., Kuechler, W., and Petter, S. (2004). "Design Science Research in Information Systems". In: URL: http://www.desrist.org/design-research-in-information-systems/.

Vriend, S. (2017). URL: https://www.gamasutra.com/blogs/SitaVriend/20170804/303075/Intrinsic_and_extrinsic_motivation.php.

Watkins, K. (2018). "The Absence of Women in Stem". In: *Medium*. URL: https://medium.com/@kodiwatk/the-absence-of-women-in-stem-fa1f8cf991af.

Wattanasoontorn, V. et al. (2013). "Serious games for health". In: *Entertainment Computing* 4.4, 231–247. ISSN: 1875-9521. URL: http://www.sciencedirect.com/science/article/pii/S1875952113000153.

Webpack. URL: https://webpack.js.org/.

What is an expert review, (2015). URL: https://www.experienceux.co.uk/faqs/what-is-an-expert-review/.

Woolley, A. W. et al. (2010). "Evidence for a Collective Intelligence Factor in the Performance of Human Groups". In: *Science* 330.6004, 686–688. ISSN: 0036-8075, 1095-9203. URL: https://science.sciencemag.org/content/330/6004/686.

Wouters, P. et al. (2013). "A meta-analysis of the cognitive and motivational effects of serious games". In: *Journal of Educational Psychology* 105(2), pp. 249–265. URL: http://dx.doi.org/10.1037/a0031311.

Zimmerman, B. J. and Martinez-Pons, M. (1990). "Student differences in self-regulated learning: Relating grade, sex, and giftedness to self-efficacy and strategy use". In: *Journal of Educational Psychology* 82.1, pp. 51–59.

Appendix A

Description of the Final Game

The game is divided into 8 parts and starts with a brief introduction to the story and ends with a battle against the ignorant mayor. The level architecture is depicted in figure A.1 which indicates the path and the various locations the player visits in the game.

The selected game mechanics are based on previous findings from the literature review in the specialisation project, results from the co-design workshop, and findings presented in Chapter 3. The classification depicted in table 3.3 provides a structured overview of both engagement elements and awareness raising objectives that has been utilised.

A.0.1 Introduction Scene

Scene Description
The player's first encounter with the game is a brief introduction to the story, the problem, and the mission. The user learns that the city she lives in is on the verge of losing all of its technology as a result of the ignorant mayor's plan to forbid it. She understands that if he is to be stopped then she will have to go out in search for people to help her do so. Along the way she meets a woman that urges her to visit various locations in the city that use technology. This will give her the knowledge she will need to battle the mayor. The woman is the first interaction the player has with the information sought to be presented in the game. The player is also given tips on how to interact with the game and the importance of collecting light bulbs. These will help her in the battle against the mayor.

Learning Goal
The aim of the game's first part is to set the scene for the player and give a

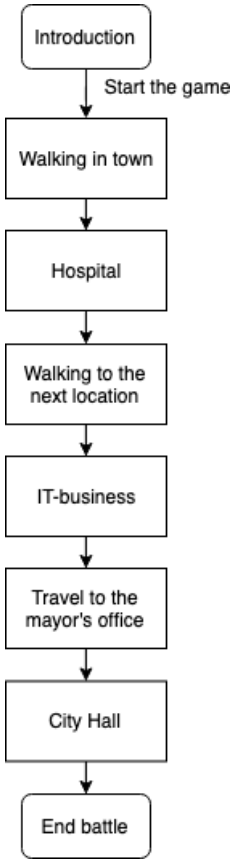


FIGURE A.1: Overview of the game presented in a diagram

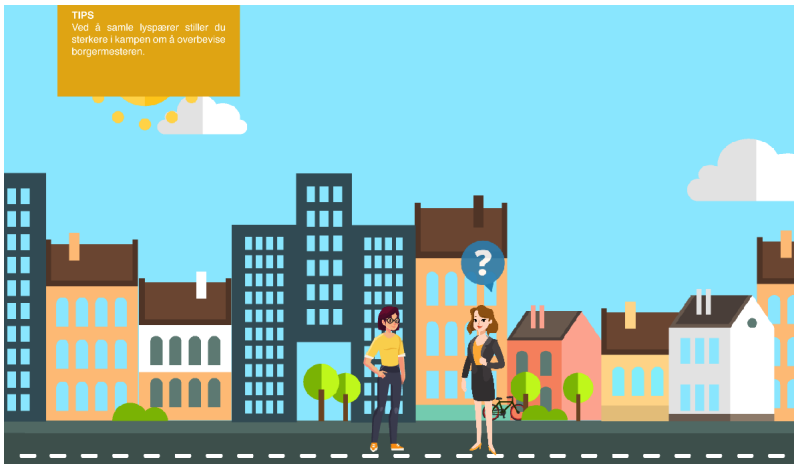


FIGURE A.2: The player can interact with characters and objects when walking to the next location

preliminary introduction to technology. The general concept of what technology is and what it can be used for is presented, setting the standard for the further gameplay. The introduction phase is also a method of letting the player familiarise herself with the game, its mechanics, the story, and the interaction with characters and objects.

Learning Elements
The player's learning outcome is an essential part of any serious game, and the use of various game elements work to enhance this. Providing information is a central game element in this part, where the woman shares her knowledge of technology with the player. Presentation of information depicted as a conversation is a more engaging method than having to read the facts in a non-contextual manner.

Engaging Elements
The introductory part is driven by the engaging game elements of the narrative and curiosity. The narrative provides the player with a story and a mission to overcome, creating an atmosphere that allows the player to immerse herself in the experience. Curiosity is tightly coupled with this as the game seeks to increase the player's spirit of inquiry to learn more about how to reach the goal. In addition, the idea of flow is considered to ensure that the first phase is simple to carry out. This gives the player a chance to get to know the game before the difficulty is increased. Short hints about how to play the game are provided to ensure a smooth start.

A.0.2 Hospital

Scene Description
During the encounter with the lady in the introduction phase, the player received a tip to visit various technology locations around the city. The first location she stumbles across is the hospital. Here the player is presented with a hospital building like the one in figure A.3. There the user will find objects and characters that are clickable, and by selecting these elements the player is taken to new scenes where information related to the clicked object will be presented.

There are four interactive scenarios in the hospital, one being a female doctor discussing technology in the health sector, another being a male doctor explaining the use of artificial intelligence in medicine, a patient with a pacemaker describing how technology keeps him alive, and lastly, a person in the waiting room wearing an activity tracker. Figure A.4 describes the game flow during the hospital scenario.

Learning Goal
The envisioned learning goal for this part is to make the player aware of the

FIGURE A.3: Representation of the hospital building as the player sees it

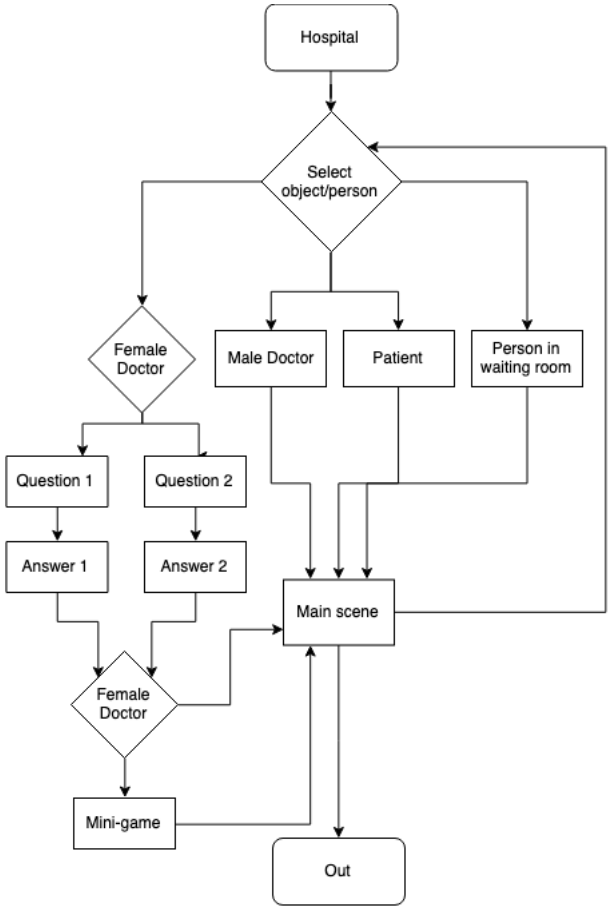


FIGURE A.4: Overview of the game flow during the hospital visit

use and implications of technology in the health sector. Health care and professions dedicated to helping others are dominated by females. By demonstrating the technology used in these professions, more people might comprehend that the health sector is not the only area committed to helping others. The goal is to illustrate the value and the impact technology can make

relying on a relevant scenario many girls find interesting.

The themes for this location are (1) general information about technology in hospitals, (2) the type of technology used, (3) how artificial intelligence is used to improve diagnostics, (4) patients' view on technology, and (5) wearables that track activity.

Learning Elements
The provision of information is central throughout all the gameplay, especially in the location visits. In this scenario, the player is presented with general knowledge about technology in hospitals. Furthermore, the player is introduced to the game aspect consequential play. She is allowed to choose the question to ask the female doctor, and her decision has consequences for the answer given. All the scenarios encountered by the player are related to real world examples, providing the user with a sense of relevance and relatability.

Engaging Elements
Since the introduction phase, the player has become acquainted with the game mechanics, thus the difficulty of the game increases. To motivate the player and keep her interested, it is important that the challenges are at a suitable level. There are several items and characters to explore that are aimed at keeping the player engaged and curious.

The player is also able to partake in a minigame to help one of the characters. The minigame is intended to sustain the player's motivation during the obtaining of information. Small hints are also provided to the player to boost her curiosity. When selecting the wearable object, the player is prompted to remember a number on the smartwatch displayed, indicating its usefulness later in the game. The player will therefore start to wonder what will happen later, increasing her motivation to continue playing.

Central game elements in this phase are (1) the player's opportunity to select what she wants to know more about, (2) choose to participate in a minigame, (3) gather light bulbs, and (4) become intrigued by a vague hint provided in the smartwatch scene.

A.0.3 Travel between the Hospital and the IT business

Scene Description
Upon leaving the hospital, the player returns to the avenue outside. It has begun to darken, and the user realises that time has passed and that the mayor's meeting is starting in only a few hours. As she hurries along the way to the next location, she is able to pick up a newspaper laying on the street. The paper contains an article describing how the mayor has already commenced turning off technology. When putting down the paper, the player receives a notification on her phone telling her that the Internet has been switched off. She then hurries to the next location which is the IT business.

Learning Goal
In this part of the game, the learning goal is to have the player reflect on a situation or scenario where technology has been deprived. This works to engage her in the situation and perhaps have her see the benefits of using technology and understanding its importance.

Learning Elements
The prominent learning elements in this scene are providing information and to benefit from the user's emotions. The newspaper is a varied and creative method of presenting information to the player which the user has not seen before. This breaks with previously used approaches to form a more diverse and interesting game. Additionally, the scene is aimed at generating emotions in the player by having them experience the time rush and the disappearing of the Internet. These are elements the target audience can relate to.

Engaging Elements
Locating objects and experiencing the gradually disappearing of technology is two of the central engagement elements in this part. The player is motivated to continue the quest when she is driven forward by elements such as the dark skies, her encounter with the consequences of removing technology, and the desire to get to the next location.

A.0.4 IT business

Scene Description

Similar to the hospital, the IT business is depicted as a building with transparency of the various office rooms. The player is then able to navigate between characters posed in different rooms and click on the ones they find interesting. There are five different scenarios at this location. (1) A female developer asking the player what her thoughts on programming are, (2) a male developer explaining the value programming holds , (3) a female programmer talking about her experience with code, (4) a room where two people are testing virtual reality equipment, and (5) a computer that demonstrates examples of what you can do with code, with emphasis on areas girls find interesting.

FIGURE A.5: Representation of the IT building as the player sees it

Learning Goal

In contrast to the hospital location where the goal was to show the player the practical use of technology and who benefits from it, the IT business is designed to demonstrate how technology is created and who is behind it. The location aspires to generate positive associations to IT and convince the player that programming is less frightening than many might think. The user is presented with relatable examples and the female developers works as a role model for young girls. This proves to them that this is not merely a boys' profession or hobby, this is something everyone can do.

Learning Elements

The main learning element of this phase is providing information. The information is presented either as a speech by one of the characters, as a image, or

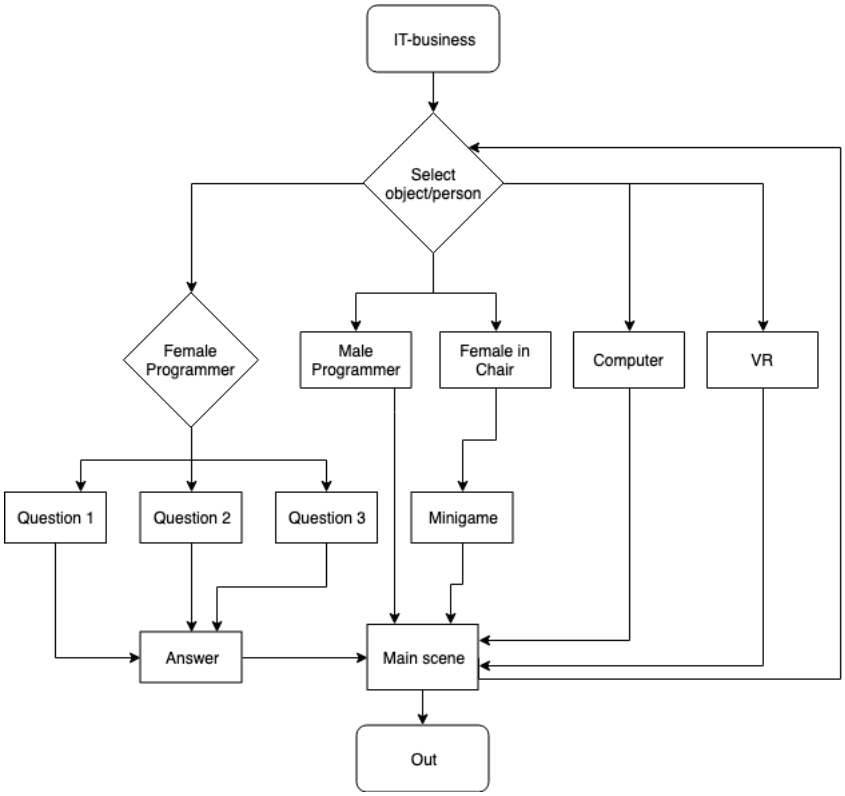


FIGURE A.6: Overview of the game flow during the IT business visit

as text in relation to an activity done by the characters or objects. The image is a new medium not previously experienced in the game and is meant as a tool to make the presentation of the information more engaging. Similar to learning elements found in the hospital scenario, the use of real world examples is also an important aspect in the IT business. Using realistic examples allow the player to identify with the characters and the information, creating a contextual learning environment.

Engaging Elements

There are several characters and objects around the office that the player can interact with. These people have been created to be relatable and charming, generating a pleasant and friendly atmosphere. This produces a safe and motivating place where the player can learn. In one of the sections, the player is able to select what programming is to her, making the choice a personal one and allowing her to feel affiliated with the information that is to be presented. Similar to the hospital location, a minigame is included to induce engagement. If the player is able to complete the minigame, she is awarded a light bulb to help her against the mayor. There is also a hidden light bulb in this location that awards the curious players later in the game and raises

motivation when allocating it.

A.0.5 City Hall

Scene Description

The IT business is currently the last location the player can visit to gain information about technology and programming. When leaving the building, the user exits out into the dark evening and is told that the mayor's meeting is about to start. However, when the player reaches the city hall, she realises that she has no way of getting inside. She must search for a means to gain access, and by glancing around the area, she will be able to find an access key. Although the key will work, the player will need an access code to get in, and if the user remembers the step count from the wearable scenario, she will secure her admission.

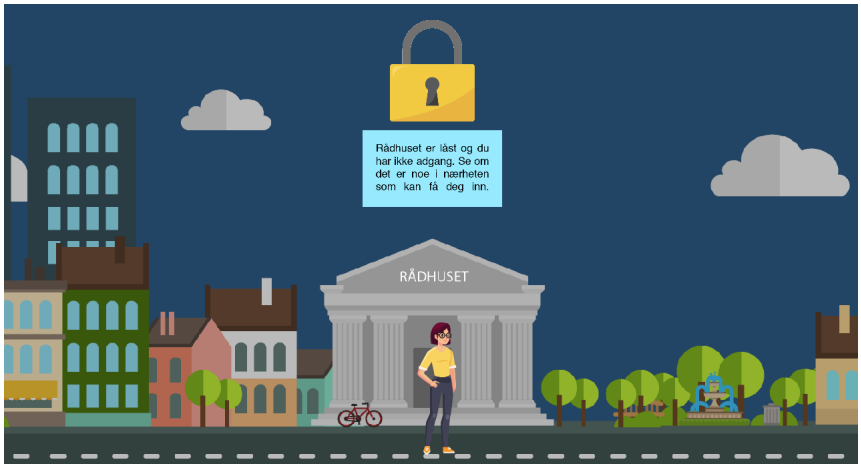


FIGURE A.7: City hall is closed and the player must find another way inside

Learning Elements

This section is meant as an engaging and fun element to break up the highly focused educational aspects featured in other parts of the game. Regardless, although it is not specifically mentioned, the phase could be relevant to security aspects of technology as it depicts the player using a lost keycard to gain access to a location she should not be. Security is not intended as a direct learning object in this game, as there are several other serious games dedicated to teaching teenagers about privacy and safety measures. Nevertheless, it is interesting to contemplate that the player might reflect on the security implication in the scenario.

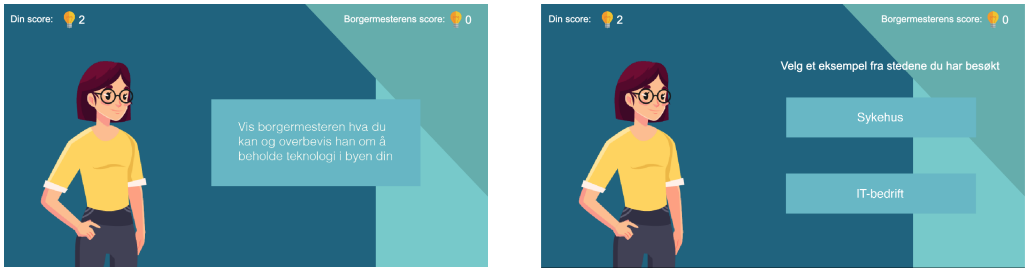
Engaging Elements

This scene is a puzzle where the player needs to find an object that will unlock the doors to city hall. It is reasonable to assume that the user has become familiar with the game and that the skill level has increased in such a manner that the difficulty of the gameplay should be adjusted accordingly. Continuous consideration of the flow state (described in section 3.1) must be conserved to ensure the player's engagement and desire to continue the game. In this scene, the unfamiliar task of solving a puzzle presents the user with a new challenge. This increases their motivation and drives them toward the final battle.

A.0.6 Battle

Scene Description

In the final level, the player interrupts the mayor's presentation about prohibiting technology from the city. This starts a debate between the two where the player must decide how to argue against the mayor's allegations and claims. Figure A.8a shows the screen before the battle is initiated, whereas figure A.8b provides a representation of how one of the choices look like.



(A) The scene before the debate against the mayor is initiated

(B) Representation of the decisions the player must make during the debate

FIGURE A.8: Scenes from the final battle against the mayor

Learning Goal

The goal of this level is to utilise the acquired knowledge from previous scenarios. Until now, the focus has been on collecting new information and gaining an understanding of how technology is applied and created. In the final battle against the mayor, the player must use this knowledge to convince him to let technology be a part of the city. The level is designed to make the player contemplate the information that has already been presented and see it in a

new context when hearing the mayor's side. The discussion facilitates reflection and an opportunity for the player to hear the other side of technology and understand the trade-offs that might exist.

Learning Elements

Repetition of previously exhibited knowledge from the game is utilised in the argument to help reinforce the user's knowledge. The tactic is widely used to boosts learning outcome (Mayer, 1983). Moreover, the player is able to select the argument she wants to use, drawing on the concept of consequential play and providing her with the opportunity to learn more about what she finds most important. The information she has previously learned will then be repeated in the conversation, resulting in an enhanced learning experience.

Engaging Elements

The battle against the mayor is the primary game element in this section of the game. It facilitates an environment that promotes user reflection and is designed to engage the user by presenting her with choices on how to proceed with the debate. This allows her to see the consequences of her actions. Because of the reflective nature of this section, the level contains few other engagement elements, other than a scorekeeper. The score allows the player to pay attention to her answers to see if she is doing better than the mayor.

Appendix B

Consent Form to Take Part in the Research Project

Forespørsel om deltagelse i forskningsprosjekt

"Hvordan få unge jenter interessert i IT?"

Bakgrunn og formål
Formålet med dette prosjektet er å undersøke faktorer knyttet til den lave andelen jenter som velger å studere data- og teknologirelaterte studier. Vi ser at en av flere årsaker for mindre interesse fra jenter er manglende bevissthet og kjennskap til temaet, samt oppfattelsen av negative stereotyper. Vi ønsker derfor med dette prosjektet å lage et informasjonsspill som skal endre dette.

Tidslinje
Prosjektet startet høsten 2018 og vil bli avsluttet juni 2019.

Hva vil deltagelse i prosjekte innebære?
Deltagelse i prosjektet vil innebære å teste et spill og svare på spørsmål i forbindelse med et intervju. Spørsmålene vil omhandle spillets evne til å engasjere og motivere spilleren, og om informasjonen presentert er tilrettelagt og på et passende nivå for målgruppen.

Hva vil skje med informasjonen om deg?
Alle personlige opplysninger vil bli behandlet konfidensielt, og vil kun bli brukt i forskningssammenheng. Dataen vil ikke bli gitt til en tredjepart og alt som kommer fram i intervjuet vil bli anonymisert og generalisert. I tilfelle informasjonen blir brukt i sammenheng med en publikasjon innenfor forskningsmiljøet, vil ikke deltakeren være gjenkjennelig. All data vil bli destruert etter prosjektets slutt.

Frivillig deltagelse
Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykke tilbake uten å oppgi noen grunn. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Samtykke for deltagelse i studiet
Jeg samtykker at jeg har mottatt informasjon om prosjektet og at jeg er villig til å delta

_____

(Navn, signatur, dato)

Appendix C

Interview Guide for Group Discussion

Spørsmål til gruppediskusjon

Relatert til spillidé

1. Er "questet"/problemet spilleren står overfor interessant og fengende?
2. Hvilke stedet burde være med?
    - Sykehus, IT-bedrift
3. Burde en bygning ta for seg flere aspekter
    - Sykehus: snakke om teknologi som hjelper folk, og medisinsk teknologi, men også folka som har laget det og hvordan det har blitt laget?

Spillet

1. Skal man kunne styre karakteren sin med piltastene eller ved pek-og-klikk?
2. Skal man kunne kontrollere samtalen man har med andre karakterer i spillet?
    - Er det en måte å engasjere og gjøre det mer morsomt for spilleren?
3. Kan mini-games være en god måte å engasjere spilleren?
    - Eksempler:
        - Hjelpe legen å finne hvor bruddet i beinet er
        - Hjelpe utvikleren å skrive kode -> trykke veldig fort på to taster
        - Quiz; men gjøre det mer personlig -> hva betyr teknologi for deg, og få svar etter hva man svarer
    - Hva er andre måter å motivere spilleren?
4. Samle objekter for å få mer poeng å stille sterkere mot borgermesteren
    - Få disse poengene når man hjelper karakterene med problemene de har

Presentasjon av informasjon

1. Kan man bruke video og andre mediaformer for å presentere informasjon på en annerledes måte?
2. Eller skal den presenteres gjennom samtaler med andre karakterer
3. Eller bare tekst
4. Forslag til andre måter å få frem informasjon i et spill?

Designspørsmål

1. Hva tenker dere om ideén bak det grafiske?
2. Kan bybakgrunnen være lik sånn den er nå?
3. Hva tenker dere om bygningene med forskjellige rom man kan "besøke" og trykke seg gjennom?
    - Tanken er at det skal gi oversikt over alt når man er der. Man får se alle teknologiene de bruker og alle som jobber og er avhengig av dem

Appendix D

Prototype Evaluation Interview Guides

Interview Guide: Pedagogy Expert

1. Hva tenker du om konseptet?
    a. Er det engasjerende og motiverende nok?
2. Hva tenker du om spillelementene?
    a. Er de engasjerende og motiverende nok?
3. Hva er dine tanker om designet?

4. Hva tenker du om områdene som har blitt valgt? Sykehuset og IT-bedriften
5. Hvilke områder innenfor IT tenker du at jenter er interessert i å høre om?
6. Hva tenker du om de personene/tingene man kan klikke på?
    a. Er de interessante for jenter og gutter?
7. Hvordan er informasjonen som blir gitt av dem?
    a. Er nivået passende for ungdomsskole/videregående?
8. Har du forslag til andre ting som burde presenteres for å øke interessen for IT?
9. Blir informasjonen fremstilt på en pedagogisk god måte?
10. Er den relevant og engasjerende?
11. Hva slags informasjon burde fremstilles for at spillerne skal få mest mulig utbyttet av spillet?
12. Hvordan kan informasjonen presenteres uten at det blir for kjedelig?
13. Kan man bruke video og andre medieformer for å presentere informasjon på en annerledes måte?
14. Hva er dine tanker om å bruke spill til å gi informasjon?

Interview Guide: Game Expert

1. Hva tenker du om konseptet?
    a. Er det engasjerende og motiverende nok?
2. Hva tenker du om spillelementene?
    a. Er de engasjerende og motiverende nok?
3. Hva er dine tanker om designet?

4. Hva tenker du om områdene som har blitt valgt? Sykehuset og IT-bedriften
    a. Reflekterer de IT-områder jenter vil være interessert i?
5. Hva tenker du om de personene/tingene man kan klikke på?
    a. Er de interessante og motiverende for jenter og gutter?
6. Hvordan er informasjonen som blir gitt av dem?
    a. Er nivået passende for ungdomsskole/videregående?
7. Er informasjonen relevant og engasjerende for jenter?
    a. Forslag til annen informasjon for å øke interessen deres
8. Hvordan kan informasjonen presenteres uten at det blir for kjedelig?
9. Kan man bruke video og andre medieformer for å presentere informasjon på en annerledes måte?
10. Hvor mye informasjon kan presenteres til en gitt tid?
11. Hvordan kan lokasjonsbesøkene gjøres mer engasjerende for å unngå at de blir demotiverende og kjedelige?
12. Hvordan kan gåingen mellom lokasjoner gjøres mer engasjerende for spilleren?
13. Hvordan kan lyspærene brukes på en engasjerende måte, feks i kampen mot borgermesteren?
14. Hva er dine tanker om å bruke spill til å gi informasjon?

Interview Guide: Target Group

1. Hva tenker du om konseptet?
    a. Er det engasjerende og motiverende nok?
2. Hva tenker du om spillelementene?
    a. Er de engasjerende og motiverende nok?
3. Hva er dine tanker om designet?

4. Hva tenker du om områdene som har blitt valgt? Sykehuset og IT-bedriften
5. Hvilke områder innenfor IT tenker du at jenter er interessert i å høre om?
6. Hva tenker du om de personene/tingene man kan klikke på?
    a. Er de interessante for jenter og gutter?
7. Hvordan er informasjonen som blir gitt av dem?
    a. Er nivået passende for ungdomsskole/videregående?
    b. Er den relevant og engasjerende?
8. Hvordan kan informasjonen presenteres uten at det blir for kjedelig?
9. Hvor mye informasjon kan presenteres til en gitt tid?
10. Kan man bruke video og andre medieformer for å presentere informasjon på en annerledes måte?
11. Hvordan kan lokasjonsbesøkene gjøres mer engasjerende for å unngå at de blir demotiverende og kjedelige?
12. Hvordan kan gåingen mellom lokasjoner gjøres mer engasjerende for spilleren?
13. Hvordan kan lyspærene brukes på en engasjerende måte, feks i kampen mot borgermesteren?
14. Hvilke debatt-temaer er engasjerende for målgruppen?
    a. Jobber, sosiale ferdigheter, utdanning, fysisk aktivitet, privacy, mental helse, miste konsentrasjon, stress, mobbing
15. Hva er dine tanker om å bruke spill til å gi informasjon?

Appendix E

Questionnaire

Spørreundersøkelse

1. **Kryss av for alternativet som beskriver deg best**
   Merk bare én boks

   - [ ] Lærer
   - [ ] Student

2. **Hva er ditt inntrykk av spillet?**
   Markér bare én oval.

	1	2	3	4	5	6	7	
Veldig dårlig	◯	◯	◯	◯	◯	◯	◯	Veldig bra

3. **Hvor engasjerende er spillet?**
   Markér bare én oval.

	1	2	3	4	5	6	7	
Veldig lite engasjerende	◯	◯	◯	◯	◯	◯	◯	Veldig engasjerende

4. **Hvem passer spillet best for?**
   Markér bare én oval.

   - ◯ Ungdomsskoleelever
   - ◯ Videregående elever
   - ◯ Begge
   - ◯ Ingen

5. **Hvem egner spillet seg best til?**
   Markér bare én oval.

   - ◯ Jenter
   - ◯ Gutter
   - ◯ Begge

6. **Tror du en spiller vil få økt forståelse av hva teknologi og programmering er ved å bruke spillet?**
   Markér bare én oval.

   - ◯ Ja
   - ◯ Nei

7. **Hvor interessant var informasjonen som ble presentert?**
   Markér bare én oval.

	1	2	3	4	5	6	7	
Ikke interessant	◯	◯	◯	◯	◯	◯	◯	Veldig interessant

8. **Hvordan var vanskelighetsgraden med tanke på målgruppen?**
   Markér bare én oval.

	1	2	3	4	5	6	7	
For vanskelig	◯	◯	◯	◯	◯	◯	◯	For lett

9. **Andre innspill eller forslag? Skriv gjerne på baksiden.**

Appendix F

Main Evaluation Interview Guides

Interview Guide Experts

Generelt

1. Hva er ditt inntrykk av spillet?
2. Hvem passer spillet for?
    a. Ungdomsskole, videregående, begge
3. Hvor passer det å spille det?
4. Hvordan påvirket spilldesignet inntrykket ditt?

Engasjement

5. Hvordan er vanskelighetsgraden med tanke på målgruppen?
6. Hvor underholdende var spillet?
7. Hva tenker du om minispillene som var på sykehuset og IT-bedriften?
    a. Gjorde det spillet morsommere?
    b. Hvilket var morsomst?
8. Hvilke elementer var mest motiverende da du spilte?
9. Hvor viktig var historien da du spilte?
10. Hva tenker du om lyspærene som må finnes og som gir spilleren en bonus i den siste kampen?
11. Hva var det meste engasjerende spillelementet?
    a. Ex: minispill, klikke på ting, velge hva du kan spørre/si, puzzle for å komme deg inn i rådhuset, finne lyspærer

Læringsutbytte

12. Hvor relevant var informasjonen som ble presentert?
13. Var det noe som ble presentert som du ikke kjente til fra før av?
14. Hvor interessant var det som ble sagt?
15. Tror du en spiller vil få økt forståelse for hva teknologi og programmering er?
16. Hvilke elementer økte bevisstheten din mens du spilte?
    a. Infobokser, samtalene med karakterene, minispillene, diskusjonen med borgermesteren
    b. Hvilket var det beste?
17. Tror du spillet kan endret synet noen har av temaene som ble presentert?

Generelt 2

18. Hvilke andre steder kunne du tenke å besøke?
19. Forslag til andre måter å presentere informasjon?

Interview Guide Target Group

Generelt

1. Hva er ditt inntrykk av spillet?
2. Hvem passer spillet for? Ung, vgs?
3. Hvor passer det å spille et sånt spill?
    a. Skolen, hjemme, på bussen (mobil)
4. Tror dere designet er med på å påvirke inntrykket dere fikk?
    a. Hvordan?

Engasjement

5. Hvordan var vanskelighetsgraden?
    a. Hva kan gjøre det vanskeligere?
6. Hvor underholdende var spillet?
7. Hva tenker dere om minispillene som var på sykehuset og IT-bedriften?
    a. Gjorde det spillet morsommere?
    b. Hvilket var morsomst?
8. Hvor viktig var historien da du spilte?
9. Hva tenker dere om at dere kunne lete etter lyspærer som kunne hjelpe dere i kampen mot borgermesteren?
    a. Ble spillet mer engasjerende pga det?
10. Hva var det meste engasjerende spillelementet?
    a. Ex: minispill, klikke på ting, velge hva du kan spørre/si, puzzle for å komme deg inn i rådhuset

Læringsutbytte

11. Kjente du til noe av informasjonen som ble gitt?
    a. Hvor mye?
12. Hvor interessant var informasjonen som ble presentert?
13. Vet dere mer om hva teknologi og programmering er og hvordan det påvirker oss etter å ha spilt?
14. Hva ved spillet gjorde at dere lærte noe nytt?
    a. Infobokser, samtalene med karakterene, minispillene, diskusjonen med borgermesteren
    b. Hvilket var det beste?
15. Tenker dere annerledes om teknologi og programmering etter å ha spilt?
16. Kunne dere tenke dere å lære mer om IT?
    a. Hvorfor?

Generelt 2

17. Hvilke andre steder kunne dere tenke å besøke?
18. Forslag til andre måter å presentere informasjon?

Evelyn Saxegaard

CITY: An Informative Serious Game to Raise Girls' Awareness of IT

NTNU
Norwegian University of
Science and Technology