Master's thesis

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

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XploreIT: A Minigame Approach to Increase Girls' Awareness and Interest in ICT

Master's thesis in Computer Science
Supervisor: Monica Divitini
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Abstract

The gender gap in Information and Communication Technology (ICT) is a major societal issue, both in education and in the technology industry. Many initiatives have tried to address this issue, and games have been proposed as a promising tool to fight the gender gap by improving girls' perception of ICT.

This research explores the design, implementation, and evaluation of XploreIT: A minigame-based serious game for teenage girls, aiming to increase their awareness and interest in ICT, which is the game's learning objective. XploreIT is based on four learning goals: Fight Stereotypes, Promote Self-confidence, Provide Role Models and Boost Knowledge.

An interview with a gender expert was conducted to study the impact of gender in the context of games. Further, a co-design workshop was designed by the authors and conducted with female university students. The results from the workshop were minigame ideas, which were the main inspiration for the serious game. Together, the interview and the workshop resulted in implications for the design of the serious game that aims to increase girls' awareness and interest in ICT.

A game expert evaluated the first game prototype through an interview. The feedback was used to improve the game before it was evaluated by N=35 female participants aged 13-16 in an online gameplay session. Pre- and post-questionnaires were used to collect data regarding the participants' experiences with the game. The gameplay data and the questionnaire data were used to determine the game's impact on the target group.

The evaluation of XploreIT showed that the game fulfilled its learning objective. The findings indicate that using minigames to increase awareness and interest in ICT among teenage girls is a promising approach. In addition, this research provides a co-design workshop that can be utilized to design minigames with specific learning goals.

Sammendrag

Kjønnsforskjellene i Informasjons- og Kommunikasjonsteknologi (IKT) er et stort samfunnsmessig problem, både innen utdanning og i teknologibransjen. Flere initiativer har forsøkt å adressere problemet og spill har blitt antydet for å være et lovende virkemiddel for å bekjempe kjønnsgapet ved å øke jenters oppfatning av IKT.

Denne forskningen utforsker utformingen, implementeringen og evalueringen av XploreIT: et minispillbasert nyttig spill (serious game) for tenåringsjenter. Spillet har som overordnet læringsmål å øke jenters bevissthet og interesse for IKT. XploreIT er basert på fire underordnede læringsmål: Bekjempe Stereotypier, Fremme Selvtillit, Gi Rollemodeller og Øke IKT-Kunnskapen. Læringsmålene skal støtte det overordnende læringsmålet til XploreIT.

Et intervju med en kjønnsekspert ble gjennomført for å få innsikt i effekten av kjønn i spillsammenheng. Videre ble en co-design workshop utviklet av forfatterne og gjennomført med kvinnelige universitetsstudenter. Resultatene fra workshopen var ulike minispill-idéer, som ble brukt som hovedinspirasjon til XploreIT. Sammen påvirket resultatene fra intervjuet og workshopen designet av spillet.

En spillekspert evaluerte den første prototypen gjennom et intervju. Tilbakemeldingene ble brukt til å forbedre spillet, før det deretter ble evaluert av N=35 jenter i 13-16-årsalderen i en digital spilløkt. Et spørreskjema ble besvart før og etter jentene spilte spillet og samlet inn data om spillernes opplevelse av XploreIT. Spilldataen og svarene fra spørreskjemaene ble brukt til å si noe om spillets innvirkning på målgruppen.

Evalueringen av XploreIT tyder på at spillet oppfylte det overordnede læringsmålet. Funnene indikerer at bruken av minispill for å øke bevisstheten og interessen for IKT blant tenåringsjenter er en lovende metode for å minske kjønnsforskjellene i bransjen. I tillegg bidrar denne forskningen med en co-design workshop som kan brukes til å designe minispill med spesifikke læringsmål.

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We would first like to thank our supervisor Monica Divitini for being a great motivator and advisor throughout this project. She has helped us with expert knowledge and provided insight into the research field. We would like to recognize the invaluable assistance and support that she has provided during this research.

Secondly, we want to show our gratefulness towards the company Attensi for letting us use their game development platform and for their assistance throughout the project. The platform allowed us to focus on and prioritize the research rather than the development of XploreIT.

We will also like to show our gratitude to the experts that participated in this research. Thanks to the gender expert for giving us valuable insight into gender in the context of games. Furthermore, thanks to the game expert for evaluating the first prototype of the game.

We would like to thank the female students who participated in our co-design workshop. Lastly, we want to thank the teachers for allowing us to have the game activity during school hours and the teenage girls for participating in the evaluation of XploreIT.

Cathrine Akre-Aas, Ingrid Kindem

Trondheim, June 1, 2021

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Acronyms

DSR Design Science Research.

ICT Information and Communication Technology.

MDA mechanics-dynamics-aesthetics.

NPC Non-player character.

NSD Norwegian Center for Research Data.

NTNU Norwegian University of Science and Technology.

STEM Science, Technology, Engineering, and Mathematics.

1 Introduction

1.1 Motivation

In computer science education and careers, there is an enduring gap between female and male participation. For instance, at a global level, only 29.2% of the students in ICT studies were female in 2016 (Sey and Hafkin, 2019). The gender gap is also present in the big technology companies: Google reported in 2018 that women represented less than one-third of the total workforce, and only 10% of the machine learning employees were female (West et al., 2019). There is a clear gender gap in the field, which is worrying as technology is a massive part of the everyday life of both men and women. The ICT gender-equality paradox, presented by Stoet and Geary (2018), demonstrates that countries with high gender equality have the most significant gender gap in Science, Technology, Engineering, and Mathematics (STEM) education and careers. Unfortunately, Norway is an excellent example of this phenomenon. In 2018, Norway was ranked as the second most gender-equal country on a global basis, but when it comes to gender equality in the ICT field, only 15.87% of the graduates of ICT programs in Norway were female (West et al., 2019).

Not surprisingly, the lack of gender diversity in ICT has had its consequences. McKinsey's study states that teams of gender diversity perform better than single-sex teams (Hunt et al., 2015). The lack of females in ICT affects both genders as team performance could improve and lead to even more innovative and including technology than the single-sex teams produce. An example of this is biased artificial intelligence algorithms, as seen in Google's speech recognition software reported as 70% more accurate on male voices than female voices (West et al., 2019). As these

examples illustrate, both in education and work, there is a well-known problem with the limited number of women in ICT (Beede et al., 2011). Thus, many initiatives are addressing this societal challenge through creating awareness of ICT among teenage girls.

Game playing has been proposed as a promising approach to improve girls' attitudes regarding pursuing computer science (Emembolu et al., 2019; Sharma et al., 2021). Serious games can be used for educational purposes and are defined as games with another primary purpose than entertaining (Susi et al., 2015). According to Bellotti et al. (2013), serious games have a two-fold goal: be educational and entertaining for the player. When addressing educational games, one must distinguish between minigames (mini-game, mini game) and complex games (Prensky, 2005). Compared to a complex game, which can be played for many hours, a minigame is a small game that can be played in a short period (Jonker et al., 2009). When minigames focus on a single theme or learning objective, it is called a serious minigame (Smith and Sanchez, 2010; Illanas et al., 2008). According to De Jans et al. (2017), using serious minigames can be a good approach to increase awareness, as it captures the player's interest in a topic in only a short amount of time.

This thesis focuses on the design, implementation, and evaluation of a serious game aiming to increase awareness of and interest in ICT among teenage girls. The game will consist of minigames that work towards the learning goals of the game. Overall, the game should introduce the players to ICT and present the importance of the field for society, which can increase awareness and spark an interest that can help to close the gender gap in the field. The thesis will also determine whether using minigames for increasing awareness and interest in ICT is a good approach for this specific target group.

1.2 Context

This study is a Master's Thesis done in the context of the Department of Computer Science at Norwegian University of Science and Technology (NTNU). The thesis builds upon results found in a specialization report written by the authors. The

specialization report is summarized in Akre-Aas et al. (2021), which is attached in Appendix A.1. The project revolves around promoting ICT studies to teenage girls. The specialization project investigated how to design games to address the gender gap with teenage girls as the target group and presented a set of game design guidelines. This Master's Thesis investigates the design and implementation of a serious game to increase girls' awareness and interest in ICT. Professor Monica Divitini supervises the project.

1.3 Research Questions

This research will investigate the use of a serious game to increase awareness and interest in ICT among female secondary school students. The results from the authors' work in a specialization report will be the basis for this research. Namely, game design guidelines and learning goals from Akre-Aas et al. (2021) will be used as inspiration to create a serious game for girls. This research will cover the development of a minigame-based serious game through design, implementation, and evaluation. The research goal of this thesis will be:

RQ1 *How can a minigame-based serious game be designed to increase awareness of and interest in ICT among female secondary school students?*

As mentioned, the game will have several learning goals that together could increase girls' awareness of and interest in ICT. In order to fulfill these goals, an approach using minigames will be used as it allows the player to focus on one learning goal at a time. Then, the game in total, including all the minigames, will work towards the same learning objective: to increase the awareness and interest in ICT among teenage girls. Thus, a part of this study will be to find out:

RQ1.1 *How can minigames be designed to fulfill the learning goals?*

The design of the minigames can not achieve the learning objective on its own; the minigames have to have game content that works towards increasing awareness and interest in ICT. Further, it is important to determine what game content to avoid

to prevent reinforcing stereotypes and gender inequality. Therefore, a research question that aims to find the most suitable game content is added:

RQ1.2 *What kind of game content is most suitable for achieving the learning goals, and altogether increase awareness of and interest in ICT?*

Lastly, this research aims to gather insight into the impact the final game has. Therefore, to know if the approach using minigames with the design inspired from the findings from **RQ1.1** and **RQ1.2** could increase teenage girls' awareness of and interest in ICT, the prototype will be tested with the target group. Thus, the last research question will be:

RQ1.3 *To what extent does the minigame-based serious game increase female secondary school students' awareness of and interest in ICT?*

All in all, the combination of the answers to **RQ1.1**, **RQ1.2**, and **RQ1.3** will contribute to answering the main research question.

1.4 Research Method

The chosen methodology for this research was the DSR methodology because of its guidelines on iteration and evaluation of research on information systems (Hevner and Chatterjee, 2010). The methodology's key characteristic is that it seeks to extend the boundaries of current research by creating new and innovative artifacts that solve practical problems based on theoretical and conceptual knowledge (Hevner and Chatterjee, 2010). DSR projects consist of three closely related cycles. The first cycle, the relevance cycle, provides opportunities for discovering requirements and field testing. The rigor cycle is the second cycle, which includes existing theories to the knowledge base. The third cycle is the design cycle, which is the core of every DSR project. This cycle facilitates an iterative construction, evaluation, and refinement of a design artifact. An overview of the different cycles is illustrated in Figure 1.1.

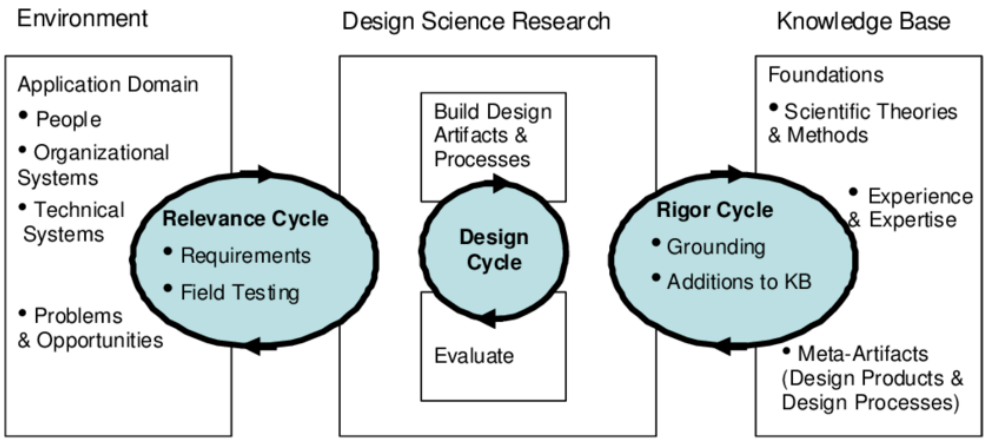


Figure 1.1: DSR cycles reprinted from Hevner and Chatterjee (2010)

This Master's Thesis builds upon a specialization project researching how to design a serious game to promote ICT studies to girls in secondary schools (Akre-Aas et al., 2021), which corresponds to the first phase of the design science research process. It covered the relevance and rigor cycle, as well as the first iteration of the design cycle. In Akre-Aas et al. (2021), the research resulted in a list of 19 game elements that are believed to suit girls' preferences in games. These game elements were categorized according to the mechanics-dynamics-aesthetics (MDA)-framework (Hunicke et al., 2004). The game elements were combined with influential factors to design guidelines on how to design games addressing the gender gap in ICT. These guidelines are the first iteration of the design cycle of the overall research. Thus, the study resulted in 16 game design guidelines in which the purpose is to support the design of a game aiming to address the gender gap in ICT. An overview of the connection of the work from the specialization report and this Master's Thesis is presented in Figure 1.2.

This research investigates the design of a serious game designed specifically for promoting ICT careers to girls in lower secondary schools. This thesis is the second phase of the design science research process, and an overview of the processes in this Master's Thesis is illustrated in Figure 1.2, as presented with connected work from the specialization project. An interview with a gender expert and a co-design workshop with female students studying technology studies will be conducted,

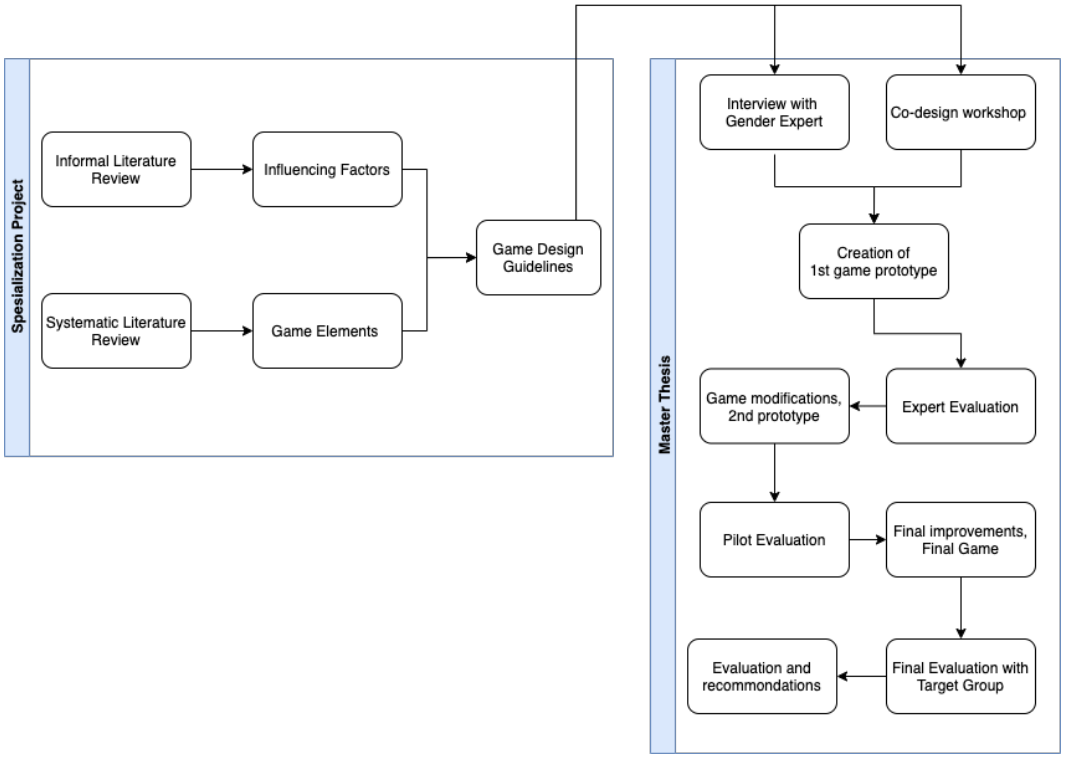


Figure 1.2: The project, as presented with connected work from the specialization project

where both will revolve around the results from the first phase and the four learning goals of the game. This process will be a part of the rigor cycle and give insight into designing the game. Several minigame design ideas, which aim to fulfill one or more of the learning goals, will be created during the workshop and used to answer **RQ1.1**. The interview with the gender expert will give insight into gender in the context of games and design. A combination of the results from the gender expert interview and the results from the co-design workshop will be used to answer **RQ1.2**. Further, these results will be used to conclude the high-level requirements and the minigame tasks, which will be the implications for the design. Then, the insight gathered in the rigor cycle will be used in the design cycle, where the first game prototype will be developed. The serious game will be developed using a game development platform with available minigame templates that can be used to design the game. This ensures a stable and complete prototype that can easily be refined and improved in the next iteration of the design cycle.

The first prototype will be evaluated through an interview with a game expert. This process will both be a part of the design and rigor cycle, as it evaluates the existing artifact and adds new knowledge to the knowledge base. The new insight will lay the basis for the next iteration of the design cycle, where the improvements for the second prototype will be made. Then, a pilot test will be conducted to test the second prototype. The results will refine the game before the final evaluation with the target group, which will be the final iteration of the design cycle. The final evaluation of the game will be done by having participants from the target group playing the game and answering a questionnaire before and after they have played the game to measure the game's impact. Finally, the game results and results from the questionnaires will be analyzed in order to answer **RQ1.3**.

1.5 Results

The results in this study contribute to the field of serious games aiming to close the gender gap in ICT in multiple ways:

- A co-design workshop that could be used to design minigames that support specific learning goals
- Additional knowledge about gender in the context of games and ICT
- Additional knowledge about the design of serious minigames
- XploreIT: A minigame-based serious game, aiming to increase girls' awareness and interest in ICT and an evaluation of its impact
- A discussion of the potential of minigames to close the gender gap in ICT

The results are acquired through a review of related work, a co-design workshop, an interview with a gender expert and a game expert, and a final evaluation of the game with the target group.

The serious game developed in this research consists of six modules. The first module is Introduction, and the following four modules correspond to the learning

goals: Fight Stereotypes, Promote Self Confidence, Provide Role Models and Boost Knowledge. The last module is the Wrap-up-module. The modules consist of several minigames that all together work towards increasing the player's awareness and interest in ICT. The prototype is evaluated in three iterations: An expert evaluation of the first prototype, a pilot evaluation, and a final evaluation with the target group.

The main contribution of this research is the results regarding the evaluation of XploreIT. The findings show that XploreIT increased the players' awareness and interest in ICT. The increase was highest among the 15-16-year-old girls, but the 13-14-year-old girls reported a higher awareness and interest in ICT after playing the game. The increase was also higher among the ones who performed well in the game. Our findings suggest that using minigames to increase girls' awareness and interest in ICT is a promising approach.

1.6 Outline of the Report

This Master's Thesis consists of 11 chapters. Chapter 2 elaborates on the problem and presents the results from the specialization project used as background for this research. The related work on minigames is presented in Chapter 3. Chapter 4 presents the process and results from the interview with a gender expert. The design and results from the co-design workshop used to design minigames are presented in Chapter 5. The implications that Chapter 4 and 5 has had for the design of the game is presented in Chapter 6. The evaluation of the first prototype is presented in Chapter 7, and the final game, XploreIT, is presented in Chapter 8. XploreIT is evaluated in Chapter 9, describing the pilot test of the game, the results from the gameplay, and questionnaires from the evaluation with the target group. Then, the results are discussed (Chapter 10) and concluded (Chapter 11).

2 Problem Definition

The following chapter describes the problem definition for this master's thesis. This research revolves around the development of a serious game to increase teenage girls' awareness and interest in Information and Communication Technology (ICT). Findings from the authors' previous research, a specialization report, will work as a foundation for this thesis.

Akre-Aas et al. (2021) contains a summary of the findings from the specialization report, together with examples of the use of the guidelines from Section 2.2. The paper is a preliminary version accepted for the 6th International Conference on Smart Learning Ecosystem and Regional Development[1]. The preliminary version is attached in Appendix A.1.

2.1 Summary of Specialization Report

This section summarizes the results from Akre-Aas et al. (2021), which is the background for this research. In Akre-Aas et al. (2021) the authors identified four learning goals that a serious game can have to promote ICT to female teenagers. The four learning goals are: Promote Self-confidence, Fight Gender Stereotypes, Promote Subject Knowledge, and Provide Role Models.

[1] `http://slerd2019.uniroma2.it`

Learning Goals

Promote self-confidence addresses the issue of girls' lacking confidence, which can be promoted through game elements. Getting stuck in a game can decrease confidence and discourage the player. Hence, providing guidance so that the player could move forward can prevent this from happening. Additionally, including positive rewards or achievements can create confidence. To fight the stereotypes in ICT, including a realistic game world with realistic avatars with all types of programmers, from female programmers to nerdy boys, can show the diversity in the field. Further, graphics can showcase a diversity of people and disprove the common belief of only nerdy guys.

To get interested in ICT, one must be aware of what it is. Providing programming as the learning objective and goal of the game can promote Science, Technology, Engineering, and Mathematics (STEM)-careers to girls through serious games. The game can create awareness and possibly increase the player's knowledge of ICT through problem-solving tasks. Girls would benefit from having role models to be encouraged to pursue an ICT career. Role models could be female teachers, parents, or other female role models in STEM. A well-known issue in ICT is the fear of being the only girl in the class or the workplace. To prevent this, playing a collaborative game could create a feeling of belonging in the ICT field through social interaction.

Game Design Guidelines

In Akre-Aas et al. (2021), game elements that are reported to have a positive impact on girls' game experiences were identified through a systematic literature review. These game elements combined with the learning goals resulted in a set of sixteen game design guidelines. The following list is a reprint of the guidelines for games design aiming to address the gender gap by Akre-Aas et al. (2021):

- **G1**: *Guidance through hints:*
  - **G1a**: *To proceed in the game*

  - **G1b**: *For assistance in the game*
- **G2**: *Positive rewards or achievements: to increase confidence*
- **G3**: *Positive feedback on player's performance*
- **G4**: *Status as a visualization of learning progression*
- **G5**: *Customization of the player's avatar*
  - **G5a**: *To identify with the avatar*
  - **G5b**: *To remove stereotypical images of programmers*
- **G6**: *Realistic game world with realistic avatars that shows the diversity in the field*
- **G7**: *Good graphics which combat the stereotypes*
- **G8**: *Awareness of ICT as the learning goal*
- **G9**: *Problem-solving tasks to facilitate learning programming*
- **G10**: *Incorporation of creative tasks*
- **G11**: *Constructive feedback on tasks, which trigger reflection*
- **G12**: *Non-player-character: Design a range of avatars that the player can choose to be the Non-player character (NPC)*
- **G13**: *Feedback provider: Use the selected NPC. Will act as a role model and disprove stereotypes*
- **G14**: *Collaborative gameplay*
- **G15**: *Non-violent content*
- **G16**: *Avoid sexualisation of female characters*

2.2 Girls and Games

According to the Children and Media Survey (Medietilsynet.no, 2020), 69% of the Norwegian girls in the age 13-16 years reported playing online or computer games in 2020. As the authors in Akre-Aas et al. (2021) concluded, a promising approach to increase girls' interest in ICT could be through serious games. Serious games have the primary objective to learn or help to practice a skill rather than entertain and amuse the player (Clark, 1970). Thus, learning through games is an effective method for assisting and improving the learning outcome. Studies analyzed in Akre-Aas et al. (2021) show that girls and boys can be engaged by different game elements, for instance, differences when it comes to preferences of collaborative, competitive, or individual gameplay (Admiraal et al., 2014).

Providing programming as the learning objective and goal of a game facilitates learning programming. This approach is recommended by Alserri et al. (2017) and Sharma et al. (2021) because it could promote STEM careers to girls through serious games. There are numerous existing games to learn to program for youths. In this section, some programming games for youths will be described and discussed in the context of the game design guidelines from Akre-Aas et al. (2021).

These programming games are selected after browsing the web for children's most popular and acknowledged programming games. In addition, they represent a diversity of programming games; some are textual-based, while others are block-based. They differ slightly in the target group, but they overlap with the one investigated in this research; teenage girls. There is also a difference in game type and playtime. All in all, the authors argue that the four games presented are a representable sample of existing programming games for teenagers.

CodeCombat

One of the popular programming games is CodeCombat[2]. The game focuses on teaching text-based programming through several tasks with increasing difficulty

[2] `https://codecombat.com`

in a game world. CodeCombat is specifically designed for use in a class context, where the teacher can get an overview of each student's progress. The player can choose an avatar among several avatars with different skills. Additionally, the player can choose the programming language, choosing between Python, JavaScript, CoffeeScript, and C++.

The player can get hints to proceed in the game and get assistance if stuck in the gameplay. Additionally, the player can get feedback if the task is correctly done or not. Information about different concepts is introduced at all levels to understand what is going on. Within each level, a progress bar is shown. The game map gives an overview of the number of tasks or levels complete and remaining.

CodeCombat is a textual game but, to adjust the game for the target group, a set of suggested commands are offered at each level. The player can use these to solve the task and finish the level. Additionally, there is an auto-complete function so that the player does not need to remember the methods from level to level.

Regarding the game design guidelines, CodeCombat fulfills five of the 16 guidelines. The game has hints, rewards and achievements, status, and thus fulfilling G1, G2, and G3. The player can change the avatar. However, one can not say that the player will always identify with any avatars one can choose among, thus not fulfilling G5a. Additionally, the available avatars will not remove stereotypical images of programmers; they will more likely strengthen them because of their stereotypical looks (G5b). However, the game has problem-solving tasks to facilitate learning programming G9 and provide constructive feedback to trigger reflection as in G11. The total of five of 16 guidelines fulfilled in CodeCombat might connect to the fact that the game is not that popular among girls as it is among boys.

A study by Yücel and Rızvanoğlu (2019) enlightens gender differences in behaviors and engagement regarding coding activities through playing CodeCombat. Yücel and Rızvanoğlu found that girls did not feel welcome in the masculine game environment in CodeCombat. This finding highlights the importance of designing gender-neutral games to catch especially females' attention regarding programming activities.

Alice

Both Scratch[3] and Alice[4] are popular and widely-used tools based on block programming, teaching children computational thinking and programming. Alice's audience is mainly female middle school to university students, while Scratch is designed for children between 8-16 years. Since the design of Alice and their target group aligns more with the one this project is focusing on, compared to what Scratch offers, Alice is considered more relevant.

Alice is an object-based programming language with an integrated development environment that needs to be downloaded. Drag-and-drop of code blocks and 3D models is used to create computer animations and games in the environment. Alice is not a game itself but is included because of its popularity.

From a guidelines point of view, Alice only checks off a few. Since Alice is not a game, there are few game elements in it. Thus, a lot of the guidelines are not applicable. G5 could be fulfilled in some cases: The player can choose figures they resemble in the gallery and make this the game's main character and evolve a story around them. Further, creating a realistic game world with realistic avatars that show the diversity in the field could realize G6, but this presupposes that the game creator has knowledge about this, which is rare. Alice offers a great range of graphics, but they do not necessarily combat stereotypes, hence do not fulfill G7. The program does indeed revolve around creativity; (G10). The player can choose among a range of sprites in the gallery and use these to be the NPC (G12). The players can collaborate on the creation of games, but Alice does not facilitate it. Hence G14 is not realized. Lastly, the game does not revolve around violent content nor the sexualization of female characters, fulfilling G15 and G16.

In addition to not fulfilling many guidelines, Alice might not be suitable for people who have no experience with programming or computational thinking since it evolves around object-oriented thinking. Further, according to Chang (2014), the program lacks focus in creating programs due to its complexity and complication of 3D object design and interface.

[3] `https://scratch.mit.edu/`
[4] `https://www.alice.org/about/`

CodeMonkey

Another online game is CodeMonkey[5], which is a leading, award-winning programming game for children. The platform offers different games, which can be played directly in the browser. Among others, it contains games that have text-based, block-based, and Python-based courses. Because of the different difficulty levels, no previous coding experience is needed to start playing on the platform. All courses are designed for school, extra-curriculum, or home use. In addition to offering a learning platform for individuals, a class context is offered, where teachers can follow the students' progress. At each level, the goal is to help the monkey reach the bananas by using different codes to accomplish this. The players, therefore, have to combine their creativity with problem-solving and basic programming skills to achieve the goal.

The game fulfills half of the guidelines, to sum up: G1, G2, G3, G4, G9, G10, G15, and G16. Before one starts playing the game, an avatar has to be chosen. The different avatars range from animals to humans in different shapes and look. Therefore on could identify with the avatar(G5a) and remove the stereotypical images of programmers (G5b). However, this avatar is almost invisible in the game. Only a tiny picture of it is visible in the top right corner, where one can click it to access the profile. Therefore, since the player's avatar is not the main character, G5 can not be seen as achieved. Since the game unfolds in a jungle environment, the realistic game world described in G6 is not achieved. Moreover, the graphics are good but do not combat stereotypes. Hence G7 is not followed. The game evolves around teaching programming, not about awareness of ICT. Therefore G8 is not fulfilled. Two students could collaborate on solving the tasks, but there does not exist a built-in function that facilitates collaboration; hence G14 is not fulfilled.

[5] `https://codemonkey.com`

Grasshopper

Grasshopper[6] is a textual-based programming game available on both desktop and mobile. It is a part of the Code with Google program, which aims to give more students the possibility to code through free coding activities. The game teaches different concepts applicable to any programming language, such as strings, variables, and data structures. The player learns the basic programming concepts using JavaScript. The game has no specific target group but aims to teach programming to anyone, regardless of age and background knowledge. It introduces tasks that facilitate problem-solving and give real-time feedback to the player. Achievements are given when the player reaches different levels and acquires specific skills.

Grasshopper fulfills multiple guidelines, specifically G1, G2, G3, G4, G7, G9, G10, G11, G15, G16. Grasshopper consists of many minigames, which can be seen as lessons, where the lessons gamify programming. The tasks are designed as puzzles, where the player can see the final puzzle and use the available puzzle pieces to complete the task. The puzzle pieces contain textual commands that the player can use. Thus, the player must not type any commands. The game also has code comprehension tasks, where some lines of code are presented, and the player should choose the correct answer in a multiple-choice matter. The player can choose to play the game over a long time, learning only a tiny bit of programming each time. This learning approach is called micro-learning and is described in the context of minigames in Section 2.3.

In total, Grasshopper fulfills 10 of the 16 guidelines. Thus, Grasshopper seems promising in regards to promoting ICT to female secondary school students. However, the game's target group is quite broad, and some topics might not be relevant for the target group addressed in this study. For instance, Grasshopper has topics related to preparing for a job interview, which is not relevant for youths.

[6] `https://grasshopper.app`

2.3 Minigames

A challenge with implementing all four learning goals from Akre-Aas et al. (2021) into a serious game is to find a game concept that can cover them all. Like how the game Grasshopper implemented different concepts into lessons of minigames, the four learning goals can be separate modules in a game, consisting of several minigames supporting each learning goal.

Minigames are small games that do not take much time to play, for example, puzzles or quizzes. Minigames are often used together to create a game consisting of many minigames. In the context of a serious game consisting of minigames, each minigame can have one small unit of learning, like serious games, while all the games together work towards the overall learning objective of the game. In that way, the use of serious minigames can be encouraging through addressing a subject from different angles through a set of minigames (Frazer et al., 2007). The use of serious minigames can also be suitable when the serious game has several learning goals. While having several learning goals in a serious game can be demanding to incorporate in the same game concept, minigames make it easier. By splitting the game into several modules or levels where each module has one learning goal, the minigames in each module can work together to achieve the same learning objective.

There are many advantages connected to the development of minigames. As they are small units, a small development team can be sufficient to create the game in a reasonable time (Prensky, 2005). Minigame concepts can often be reused from existing concepts, making the design relatively intuitive. For instance, minigames like puzzles or multiple choice quizzes are easy to design. Additionally, if one needs to modify the game, it is easy to change one minigame, remove anything or add a completely new minigame to the serious game. Thus, using several minigames to create a serious game is a flexible solution.

As the learning goals from Akre-Aas et al. (2021) will be the basis for the game developed in this research, different modules can be utilized to achieve each learning goal. In addition, the flexibility of minigames is suitable for incorporating several of

the guidelines, as demonstrated in Grasshopper. Thus, using minigames to address the problem seems like a suitable approach. Additionally, as the game teaches some basic concepts to the player, microlearning can be beneficial. Microlearning (micro-learning) is the concept of learning through several short-term activities and small units of learning tasks (Hug, 2005). According to Alqurashi (2017), effective microlearning environments are dependent on content, pedagogy, and technology and can boost the learner's engagement. Microlearning is not suitable for complex concepts, as one needs to break the concept into bite-sized pieces. However, minigames can be used as microlearning resources where each minigame address a small piece of the learning unit, and in that way, promotes small bits of learning to the player. Microlearning consists of two parts: Microcontent, i.e., short-form information in the form of, for instance, videos, text, audio, and microlearning activities, which is the actual interaction with the learning content (Lindner 2006 as cited in Kamilali and Sofianopoulou (2015)). When minigames are used to implement microlearning, a challenge is balancing the play and learning aspect (Arnab et al., 2021).

This research is based on creating a serious game with four different learning goals. By using minigames as microlearning resources, the game can address each learning goal separately. Additionally, by addressing the learning goals from different angles through several separate minigames using microlearning, one can achieve increased awareness and interest in ICT among female secondary school students. For simplicity reasons, the learning goals from Akre-Aas et al. (2021) are renamed to the following, which is used in this research: Promote Self-confidence, Fight Stereotypes, Boost Knowledge, and Provide Role Models.

2.4 Game Development Platform: Attensi

Attensi[7] is a Norwegian company specialized in gamified simulation training, and their solutions combine advanced 3D modeling with deep insight into human behavior and psychology. They offer different products, which aim to fulfill different

[7] `https://attensi.com/about`

needs. One of these products, Attensi SKILLS[8] engages people with minigames and interactive challenges that inspire and inform. This product offers a range of different minigames, which can be combined to create tailored training modules. The game creation is done in Attensi CREATOR, which is a no-code development platform. Examples of minigames offered in Attensi SKILLS are multiple-choice quizzes with text or images, true or false games, and fill-in-the-blanks in a sentence. There is also an opportunity to create a dialogue with an NPC and give learning material in the form of videos, text, and pictures. In total, there is a set of 16 minigame templates available to customize into a game.

Due to this project's limited scope and time, the authors have decided to use Attensi CREATOR and SKILLS for the game development. This platform is known to one of the authors, as she has previous experience with it from earlier projects. Using a familiar platform with available resources allows the researchers to use most of the time on the problem and the game's design rather than its development. The game development platform also ensures a stable and complete prototype that can easily be refined and improved in multiple iterations. Additionally, certain processes have already been covered. For instance, there is no need for conducting a usability test as the company has done this. However, the use of a game development platform comes with certain disadvantages. The biggest drawback of using Attensi CREATOR is that the authors do not have the opportunity to change or add services or features. Hence the opportunity space is limited to what exists on the platform. The implications this has for the design are discussed in Section 6.4. For the sake of simplicity, the authors will only use "Attensi" to refer to the chosen product and the game development platform instead of Attensi SKILLS and Attensi CREATOR.

[8] https://attensi.com/solutions/attensi-skills/

3 Related Work

This chapter aims to analyze previous work on the use of minigames to gain insight into design and methods for implementing it in a serious game. It will also present previous efforts on the use of minigames to address the gender gap in Information and Communication Technology (ICT). Overall, the findings in this chapter will be used as inspiration when designing the serious game in this research.

Research has shown that serious minigames are promising tools for raising awareness, as they can be motivating and enhance the player's interest in a topic while still demanding a small time investment (De Jans et al., 2017). Additionally, De Jans et al. states that as the game is not time-demanding, it can be an ideal tool to increase awareness of a topic effectively, engaging, and collaborative.

3.1 Minigames Addressing the Gender Gap in ICT

In the context of using minigames to address the gender gap in ICT, this is done in Ertl and Zauchner-Studnicka (2020). In particular Ertl and Zauchner-Studnicka aimed at supporting motivation and self-concept among female students by using a game-based learning approach to raise motivation and interest concerning ICT. The game that was created was based on an IT-related narrative, with additional minigames to challenge the players on core competencies related to ICT. Several videos were included in the game to provide role models to the player. The game was a collaborative game, which was tested over six weeks by 13- and 14-year-old students. The 79 female students testing the game were divided into 20 teams,

and after the testing, the players participated in a focus group to discuss the game. The Non-player character (NPC) in the game was appreciated by most players, as she encouraged them throughout the game. The study showed positive results regarding change of student's attitudes regarding their perspective of ICT and women in ICT, while few were positive about ICT as a future profession. As the study was a long-term study conducted in a classroom context, teachers were trained and used teacher material. Thus, the implementations in the different classrooms might differ from the original material, which can have affected the outcomes, especially student dropout for some tasks (Ertl and Zauchner-Studnicka, 2020).

Using games to address the gender gap in ICT is also done in Saxegaard and Divitini (2019). The paper presents the research and implementation of an informative, serious game containing minigames intended to motivate the player throughout the game while obtaining information about ICT. Game elements connected to the minigames are rewards that the player can use to help in the final battle. The game created in Saxegaard and Divitini (2019) is intended to raise girls' awareness of ICT. Thus, Saxegaard and Divitini identifies several game elements from awareness-raising games. Elements like Quizzes and active game tasks, for instance, collecting items, was common game elements to raise awareness. Exercises with questions and answers were used to boost knowledge or make the player aware of the consequences of a decision.

In evaluating the game in Saxegaard and Divitini (2019), the minigames and the opportunity to decide whom to talk to and answer were found to be the most engaging element. The minigames in the serious game had no learning aspects, and this was suggested as an improvement for the game. Saxegaard and Divitini states that in an awareness-raising game, one must bear in mind that it shall be playable by everyone, and the difficulty must not be too high. To conclude, Saxegaard and Divitini (2019) states that serious games are a promising approach to raise awareness of any topic and to all genders. The use of minigames contributed positively to the game to maintain the users' interest throughout the game.

A pilot study done by Stewart-Gardiner et al. (2013) showed that girls enjoy playing games when they are designed just for them. Their study found that playing games

that teach computational thinking can influence girls to study computer science. The instructors in the game activity were females and were intended to act as role models for the girls. Both girls and boys who were between 11 and 14 years participated in the study, which lasted for five weeks. The game has minigames in the form of puzzles to teach computer concepts to the players. Timers and counters were used to check if the players learned the computer concepts embedded in the minigame-puzzled. The players had the opportunity to play the minigames several times to do repetition and improve their scores. The games created in Stewart-Gardiner et al. (2013) influenced girls to picture themselves as programmers in the future. The games were relatively static, and an improvement could be to have more adaptive and professional games.

3.2 Design of Minigames

In Frazer et al. (2007), the authors analyze three educational minigames according to their usefulness. The authors suggested creating series of minigames to help their assimilation of new knowledge. Their theory is that the knowledge provided earlier in the series is required later on, which causes a need for reflection on old knowledge in the following minigames. This is done in Arnab et al. (2021) as well. In Van Rosmalen et al. (2014), minigames are grouped in modules and must be played sequentially. The modules build on knowledge from the previous ones. Unlike in Van Rosmalen et al. (2014), the game in Arnab et al. (2021) is divided into modules where each covers individual learning goals, which can be played independently.

Bellotti et al. (2012) presents a framework to support content design to the final implementation of serious games. Their framework presents several minigame templates that they argue are particularly suited for learning about cultural heritage. The minigame templates are divided into three categories according to the cognitive skills they involve. The three categories are observation, reflection, and arcade tasks. Bellotti et al. proposes the following minigame templates:

- Manuscript: The player enters the missing words in the text from possible

answers in a drop-down menu or has to identify the wrong words,

- Image Comprehension: questions related to an image with multiple choice answers
- Quizzes, VisualQuiz: a quiz with images or written text
- Wrong or missing details: observation of wrong or missing details on an image
- RightPlace: drag-and-drop icons on their right place on an image
- Puzzle: compose an image with the available pieces
- Couples: match items in two columns
- CatchIt: an arcade game where the player should catch the right objects and avoid the wrong ones

Even though the research in Bellotti et al. (2012) is suited for games promoting cultural heritage, the minigame templates can be valid for any topic. The authors conclude that further work is needed, for instance, by extensive user testing to analyze the proposed framework. Especially exploring new minigames where the player can interact with an NPC and the 3D environment is highlighted.

In Jonker et al. (2009), the authors state that designing an educational minigame intended to use if the players are not supervised is more demanding compared to if, for instance, a teacher supervises the players in a classroom setting. Thus, all instructions need to be in the game.

3.3 Frameworks for Minigame Development

There exist multiple papers describing the design and development of serious games, where some of them have used methodological frameworks to do this. In this section, the papers focusing on minigames will be presented to find similarities between frameworks and advantages and limitations with the methods used. This

is done to gain knowledge that later can be used in the design, development, and evaluation of the game represented in this report.

De Jans et al. describes a methodological framework for co-designing serious minigames, which consist of four phases: 1) definition domain, 2) brainstorming and definition requirements, 3) design game scenario, and testing, and 4) development alpha version and testing. The research in De Jans et al. (2017) is concentrated on developing a set of serious minigames to create awareness concerning a societal problem. However, the authors believe that the framework used can be utilized for any serious game project where the contribution from various stakeholders is considered beneficial. The design of the game happens in phases 2 and 3. In phase 2, brainstorming sessions were conducted with adolescents, where both the problem and the design of serious games were the focus. The participants worked in teams and listed their most favored game feature, and made a game storyboard. The outcomes from this session were coded and used in phase 3. In phase 3, the outcomes were used to create a game world and a game concept. Also, adolescents were used to influencing the game mechanics, while experts concentrated on the game's content. The paper does not describe the development process of the game; other than that, a development team was involved in the alpha version of the game. Likewise, there is a lack of description of the evaluation process; the only thing mentioned is that there were one usability test and one test with the target group. In the evaluation with the target group, they are quizzed on questions related to the learning goal. Therefore, there is no evaluation of the game itself.

The researchers in De Jans et al. (2017) points out several advantages this framework has compared to other frameworks for serious game design. Among other advantages, it is highlighted that this framework includes the target audience in the game design process, whereas others only include experts. However, it also points out some risks this includes, as the design process will be difficult if it concerns topics that the end-users are unaware of. Further, the paper emphasizes the advantage of asking experts to participate in the research when their expertise is required the most, as it will maximize the value of their contribution. De Jans et al. also highlights specific rules which must be followed to ensure a successful project. Firstly, the game's main objective must be clearly stated. Further, a clear learning

objective should be established as a short mission statement. Lastly, feedback from stakeholders should be collected before design sessions in order for the development team to know which game mechanics and content should be integrated into the game scenario.

Van Rosmalen et al. (2014) presents a case study on the design and development of minigame for research methods and statistics. In this case study, the 4C-ID (Four Component Instructional Design) is used, which assumes that complex learning can be designed with the help of four interrelated components (van Merriënboer and Kirschner, 2012). The underlying components are 1) Learning tasks, 2) Supportive information, 3) Procedural information, 4) Part-task practice. The minigames were integrated into the learning tasks component and chosen because they fit easily into the curriculum and quickly go through the main research challenges. Van Rosmalen et al. argues that this will help to increase the students' motivation and get them excited about the research.

In regards to the design method, the paper only describes how the game content was created. This was done by using cognitive task analysis(CTA) to identify the cognitive skills, knowledge, and competencies. In addition, semi-structured interviews with several persons from the target group were conducted. The CTA, together with the results from a previously conducted literature review and the requirement analysis, resulted in a set of initial high-level requirements or guidelines. Further, the 4C-ID model was used to create the global design. The minigames are grouped in modules and have to be played sequentially, as the different modules build on knowledge from the previous. The paper does not mention how the development process took place. Further, related to the evaluation process, the evaluation was carried out in three phases. The first two phases aimed to assess the usability of the games and collect suggestions for improvements. The last one aimed to assess if the games achieved their goals, in other words: the intended learning outcomes. Both the target group and experts were involved in the evaluation phase. Although the resulting game received positive feedback, the framework is designed for games designed for complex learning, as research methods and statistics in Van Rosmalen et al. (2014), which is not the case for the game in the research.

Arnab et al. (2021) explores micro-learning and the design of minigames, based on a case study of the need for training on cultural risks in multi-cultural organizations. The design and development of the game is the last step in a three-step development process. The design process includes mapping learning mechanics against game mechanics to align the resources to the specific learning objectives they were designed for. To create the game experience, Arnab et al. selected four core aesthetic representations, based on the mechanics-dynamics-aesthetics (MDA)-framework. The four aesthetics chosen was 1) Challenge, 2) Discovery, 3) Fantasy, and 4) Expression. Why these four were selected, as well as other design choices, is not reasoned nor discussed. In addition, the aesthetics chosen do not line up with the aesthetics, which has influenced the guidelines for the game design in this report, as described in Akre-Aas et al. (2021). The game's development process is not described in detail, as the project's partners did it. The game consists of several different minigame types, divided into modules, where each module concerns a topic with a respective learning goal. The evaluation process was done in two phases by the target group: Alpha and beta testing. In both of the tests, participants had to answer questions related to the game after playing it. The questions did, among others, evolve a ranking of the minigame types, how they connected to learning objectives and a ranking of the modules.

Zaman et al. (2012) reports on two conceptual design sessions where concepts for educational minigames were generated through a human-centered approach. This paper does only address the design process, not the development and evaluation process. The first of the design sessions was a co-creation session with adolescents, the end-users, and was held to get insight into their preferences for educational games for language learning. The second was a brainstorming session with domain experts to reveal which mechanics are most appropriate for designing minigames for various educational programs. In the latter, input material was used. However, it was unclear what effect the methodological decisions had upon the brainstorming outcome. Zaman et al. stresses that the results were not intended to represent a final game concept nor concrete design guidelines for both sessions. Instead, it could provide the design team with more insights into users and their preferences and be used as inspiration rather than a limitation.

To summarize, the papers present several methods for designing, developing, or evaluating minigames. However, few of the papers go into detail about how all of the phases are solved, and one of them (Zaman et al., 2012) only focuses on one of the phases. All of the papers involve the target group in the design or the evaluation process. De Jans et al. (2017) is the only research that describes the game's actual development; hence, it is hard to say anything about the development process of minigames. In the evaluation process, several different methods are used. Usability testing is done in De Jans et al. (2017) and Van Rosmalen et al. (2014). Also, alpha and beta testing are explicitly mentioned in De Jans et al. (2017) and Arnab et al. (2021). There are not many detailed descriptions for how the evaluation is done, but three of the papers used questionnaires to do this. More specifically, Arnab et al. (2021) used questionnaires for feedback on the game, while De Jans et al. (2017) and Van Rosmalen et al. (2014) quizzed the participants on questions related to the learning goal. It should also be mentioned that three of the papers involved different experts in some of the phases (De Jans et al. (2017), Van Rosmalen et al. (2014), Zaman et al. (2012)).

The methods discussed in this section will be used as inspiration for how the research in this thesis will be conducted and used by others who intend to design, develop, and evaluate serious minigames. Firstly, experts will be involved in the phases their expertise is most needed, as this will maximize the value of their contribution. Secondly, a co-design session will be held to create the design for the game. However, the target group will not be included in the session, as De Jans et al. (2017) pointed out the risk of including the end-user in the design process if it concerns topics they are unaware of. Nevertheless, girls will be included in the evaluation of the game to get feedback from the target group. The evaluation will include questionnaires that will either concern the learning objective or the game itself.

4 Gender Expert Interview

Before creating and designing a serious game to increase awareness and interest in Information and Communication Technology (ICT) among teenage girls, it is essential to address the aspect of gender in the context of the design of games. When working for gender equality, one should consider that the game could work against its purpose by making wrong choices in its creation. In order to minimize this risk when designing a serious game, an interview with a gender expert is conducted. The results are used as the foundation for developing the game, together with results from the co-design workshop in Chapter 5. This chapter contains the purpose, process, and participants of the interview and the presentation of the results. The participant has approved the content written about her statements in this chapter.

4.1 Purpose

The purpose of the interview was to get insight into what role gender plays in design and games. Additionally, the interview should overview what is essential to consider when working for gender equality in ICT and insight into the challenges and benefits of gender-specific design. To discuss the learning goals and get feedback on which of the guidelines were more or less critical was also a purpose of the interview.

The interview with the gender expert aims to increase the authors' insight about gender in the context of games and ICT to ensure that the resulting artifact in this research will not have the opposite effect of what is intended.

4.2 Participant

The gender expert works as a senior researcher and has worked on gender equality in organizations. She has been teaching about gender, especially in innovation processes and ICT. Within ICT, she has focused on toxic algorithms and how machine learning can reinforce gender inequality. When she approaches new topics in her work, she sees them through a gender lens and perspective. The authors had previously attended a conference on technology bias, where the participant was a speaker. Thus, she was familiar to the authors and asked to participate.

The participant signed a consent form before participating in the interview. The consent form included information about the project and details on how the data will be used and stored. Additionally, the consent form contained information regarding the participant's rights. The consent form is found in Appendix D.1.

4.3 Process

The interview was initiated by introducing the project and the purpose of the interview. A description of the problem, the previous work done by the authors, and the planned work were described. Then, the questions were asked according to a predefined interview guide, which can be found in Appendix B.1. The main topic of the interview was gender in the context of games. The questions revolved around the authors' previous work: the learning goals and the game design guidelines. These were presented to get insight into what is essential to focus on and avoid when working for gender equality. The interview was semi-structured, and the questions in the interview guide were not always asked in the same order, but more when it was natural according to the conversation and topics addressed. Additionally, some follow-up questions not included in the interview guide were asked when the interviewee addressed exciting topics that the researchers found necessary to discuss further.

The interview was conducted digitally through Zoom. Data were collected through Zoom's built-in voice-recording function. Norwegian Center for Research Data

(NSD) approved the data collection before the interview was conducted. After collecting the data, the recording was transcribed, and the results were analyzed.

4.4 Results

The following section contains the results from the interview. The interview was transcribed and analyzed by both authors. Afterward, the main topics were extracted. Then, the transcribed interview was thematically analyzed, following a six-step procedure (Braun and Clarke, 2006):

1. Familiarize with the data
2. Generate codes that describe the content
3. Search for themes
4. Summarize the themes
5. Define and name the themes
6. Write down the results

4.4.1 Games

When asked about her thoughts on using a game to address the gender issues in ICT, the interviewee thought it was a good idea in principle and had knowledge about games being used in schools to promote other issues. She also added that games played during school time could be an excellent way to teach gender and gender equality and influence girls' choices. In addition, she mentioned that the game should target younger students since their gender identity is not fully formed. In that way, one can influence their process of self-definition.

The interviewee did not think that a gender-specific designed game could have a negative effect in itself. However, if not appropriately designed, a gender-specific

design could work against its purpose. She illustrated this by using women-only carriages, which addresses the problem related to sexual harassment. She thought it was essential to bear in mind that a women-only carriage within ICT is neither the goal nor the solution to the problem; the whole of ICT needs to be a safe space for everybody, and it is about changing the mentality within ICT at a more extreme level and should be kept in mind during the design and creation of the game.

Further, the interviewee emphasized the importance of monitoring how the girls play and perceive the game. Since they are the end-users of the game, she suggested that information should be collected from girls before and after the game is given to them to attempt to see its impact.

When asked about the designs' influence on the game's effectiveness, the interviewee stressed that the presentation of it was crucial. She suggested that the purpose of the game should be emphasized and permeate the game. During the interview, a common problem related to gender-neutral programming games was mentioned. The interviewee thought it was interesting how games designed for boys and girls can be liked more by boys, almost as if they were designed for this gender. She suggested that this might be due to most male developers but more likely relate to how deeply rooted gender assumptions are.

Lastly, related to the topics of games, the interviewers asked if she had some interesting examples that could be used in the game to illustrate the importance of gender diversity in the ICT field. She mentioned a book called Technically Wrong by Sara Wachter-Boettcher (Wachter-Boettcher, 2017), which had multiple relevant examples. She highlighted the Apple Watch made for girls but made by men, a fiasco withdrawn from the market. Moreover, Amazon's AI recruiting tool, which showed a bias against women, was mentioned.

4.4.2 Gender Diversity in ICT

When asked about gender diversity in ICT, the interviewee had two perspectives: diversity in terms of employee demographics and diversity as the inclusion of gender

perspectives in product design. She argues that the two perspectives influence each other since the demographics somehow determine whose viewpoint is considered when designing products. She also adds that women not choosing an ICT career might be a consequence of the lack of role models.

The interviewee says that *"Change is something that has to be promoted, it has to be pushed. It doesn't happen by itself."* Further, she argues that change will happen slowly since the number of women in ICT has slightly increased in the previous years, but it will not happen naturally. *"We have to promote it. We have to support it. Alternatively, these mechanisms are so ingrained that they will perpetuate."*

4.4.3 Learning Goals

When asked about the learning goals: Fight Stereotypes, Boost Knowledge, Provide Role Models and Promote Self-confidence, the interviewee thought self-confidence could not be promoted without fighting stereotypes. Thus, these goals were suggested to combine into one goal, which the interviewee thought was the most important goal. *"Promoting self-confidence through fighting stereotypes is the most important."* Additionally, the gender expert stated that a stronger emphasis on providing role models was wanted, which could be done as a part of the game, but also a part of the activity with the teenage girls. During the activity, the gender expert advised both to talk about women working in ICT, what they do, and telling it in an understandable way for a young learner. Additionally, she pointed out that the authors, as female computer science students, will be role models for the participants.

The interviewee emphasized that one should not create a small safe space for girls, as it can make the rest of ICT seem dangerous to enter. Further, the gender expert stated that fighting stereotypes were the most challenging learning goal to achieve. *"Because as you fight them, you always run the risk of recreating them, and this is the biggest concern of gender researchers. Fight without reinforcing, fight without recreating".* Additionally, the language used in the game is essential when the work is presented to the teenagers if the game is language-based. Significantly, the interviewee warned about using metaphors again not to create a girls-only safe

space. One must make sure that girls understand that they are allowed in the whole ICT, not only in this game or similar. The gender expert mentions the metaphor "Flink Pike" in Norwegian, which is a stereotyping metaphor. Thus, stressing that metaphors like this could reinforce stereotypes. *"These kind of labels, gendered labels for both boys and girls should be avoided."*

However, the interviewee thought that Boost Knowledge was not that important, as the number of resources available is plenty for both boys and girls. *"It is other mechanisms that keep girls away from ICT."* Additionally, the gender expert stated: *"I don't think it's lack of knowledge that drives women away from ICT."* Thus, the interviewee said that going to schools and explain to girls how interesting and important it is for women to get interested in ICT is good, but not the most important of the four goals, as girls in Norway have ICT knowledge.

4.4.4 Game Design Guidelines

When the gender expert was asked about the game design guidelines, some were extracted as more or less critical. First, the avatar was mentioned as being just as crucial as the metaphors described in Section 4.4.3. An avatar is a label that sums up a person in a few words, and the avatar is somewhat one's virtual self, as mentioned by the gender expert. Additionally, the interviewee stressed the importance of avoiding the sexualization of female characters and that customization of players' appearance is essential, allowing the player to express as much individuality as possible. Thus, the gender expert thought that keeping an eye on which customization most girls choose could be interesting. However, the gender expert was not that fond of having realistic avatars. *"Avatars are never realistic, they can be diverse, but I would not aim for realism because realism is always our selection of what we see. Realism is filtered through our interpretation of reality."* Thus, it was stated that showing diversity in skin tones, kinds of eyes, body weight, and more are essential, but representing real people with avatars is difficult.

Again, similarly as in Section 4.4.3 about providing role models, the gender expert said to make sure the authors put themselves forward as role models. Awareness of ICT as a learning goal was thought to be fundamental. Additionally, incorporating

creative tasks and giving constructive feedback were considered necessary. However, the gender expert thought that the feedback should be brief and very simple, as the target group is young learners that might be bored if it is too much text in the game.

The main takeaways from the gender expert interview are the different considerations one must make when designing a game working for gender diversity. The gender expert has provided insight on the learning goals, which to focus the most on, and which learning goal is the most challenging to achieve. Regarding the game design guidelines, the expert has provided suggestions on which is essential and not. However, the implementation of the game design guidelines is also dependent on the final game concept and the type of technology used to implement the game. The results from this interview will, together with the results from the co-design workshop (Chapter 5), implicate the design of the serious game in this research. The impact the gender expert interview has on the design is described and discussed in Chapter 6.

5 Co-design Workshop

This chapter describes a co-design workshop for increasing girls' awareness and interest in Information and Communication Technology (ICT) through minigames. This method was chosen to involve participants who have insight and understanding of the problem in the creation of minigame design ideas that supports the learning goals. Also, this method facilitates idea generation and brainstorming.

5.1 Purpose

The purpose of the workshop is to create specific minigame design ideas for the serious game by using the learning goals. Additionally, the minigame ideas created in this workshop could give insight into which minigames are favored more. Further, the workshop results will give an impression of which learning goals are relevant to implement and which tasks the participants think will increase the awareness and interest in ICT the most. Lastly, since the workshop facilitates creativity and idea generation, it will most likely give a wide specter of minigame ideas, which will be beneficial for creating a variety of tasks in the serious game.

Summarized, the objectives of the workshop are the following:

- To create specific minigame design ideas
- To get a wide specter of minigame ideas
- To gain insight into which types of minigames that are favored
- To get an impression of which learning goals that are relevant to implement

- To get an impression of which minigames will create the most awareness and interest in ICT

The results from this workshop are not intended to be finished game concepts or minigame designs but ideas for the authors to base the serious game design on. However, the results provide the authors with insight into the wide range of minigame ideas that can be implemented in the serious game.

5.2 Process

First, the co-design workshop was designed by the authors. This process is described in Section 5.3. The chosen workshop tool was Miro[1]. Miro is a digital whiteboard where one can collaborate online and was chosen due to the authors' familiarity with it. In addition, it is a flexible tool that has several different features suitable for workshops. After the workshop was designed, a pilot workshop was held to test the workshop design, including the time estimates, the task flow, and assets created in the workshop tool. This process is described in Section 5.4.

Nine girls were recruited to participate in the workshop, aiming to design tasks for the serious game for girls. The participants were divided into three groups, where each group attended separate sessions. The authors facilitated the workshop sessions. The workshop process and results are described in Section 5.5.

Both the pilot workshop and the co-design workshop were conducted digitally through Zoom, using the sketching software Miro to be creative together. The sessions were voice-recorded on Zoom to capture discussions throughout the tasks and let the authors focus on observation rather than taking notes from the discussions.

[1] `https://www.miro.com`

5.3 Design of the Co-design Workshop

The workshop was designed by the authors, with inspiration from the Design Sprint described in Knapp et al. (2016). The Design Sprint has a duration of five days, where each day is a step in the process. In this co-design workshop, methods and inspiration have been taken from the second and third days. In the Design Sprint, the second day is used to develop solutions, where the day starts with inspiration and follows with the sketching of different ideas. On the third day, the solutions designed during the second day will be reviewed, voted on, and improved.

The co-design workshop, which is designed and described in this paper, consists of 8 phases: (1) Introduction, (2) Reflection, (3) Ideation, (4) Creation, (5) Dot-voting, (6) Iteration, (7) Dot-voting with modifications, and (8) Evaluation and wrap-up. The eight workshop phases are described in detail in Section 5.3.2 to 5.3.9. An overview of all the phases and their respective main objective is shown in Figure 5.1.

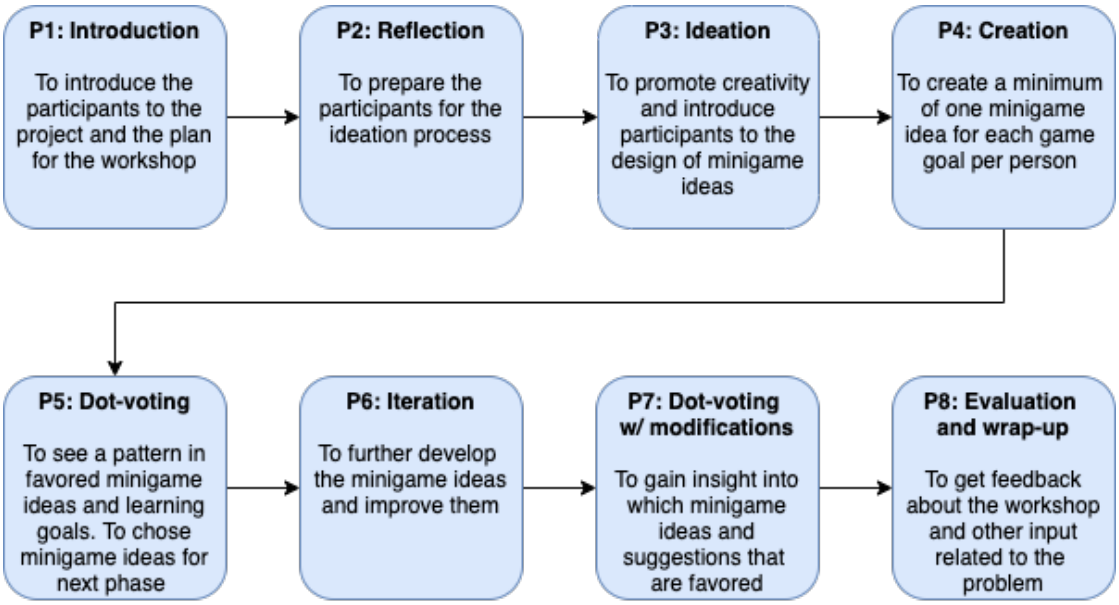


Figure 5.1: The workshop phases and their main objective

5.3.1 Assets

First, before describing the different phases of the workshop, the **Assets** used in the workshop need to be addressed. Assets refer to any resource used as a tool in the workshop to help the participants execute the tasks and support the facilitators throughout the workshop session. All the assets are digital. The following subsections describe the assets used in this workshop.

Board and Frames

In Miro, each of the workshops is conducted on one *Board*, which can be described as the work area which all participants share. The board is divided into different *Frames*. Frames are areas that the user creates and defines. Each of the frames represents one of the eight phases in the workshop. Having the frames makes it easy for both the facilitators and the participants to understand which area and task one should work on in each phase. The frames are illustrated in Figure 5.2, with the frames from phase 1 and phase 2 as an example. The white box around each phase is a Frame.

Post-its

Post-its are important assets of the workshop. The post-its can be dragged around and can contain text, which participants can type in. The text's font size depends on the amount of text within the post-it; hence, it changes automatically while the user types it. The post-its can be placed on top of each other in *post-it stacks* and can have different colors and sizes. The post its are shown in the Reflection frame in Figure 5.2 as the orange, green and yellow stacks. In phase six, Iteration (Section 5.3.7), this feature is utilized to separate the participants' suggestions.

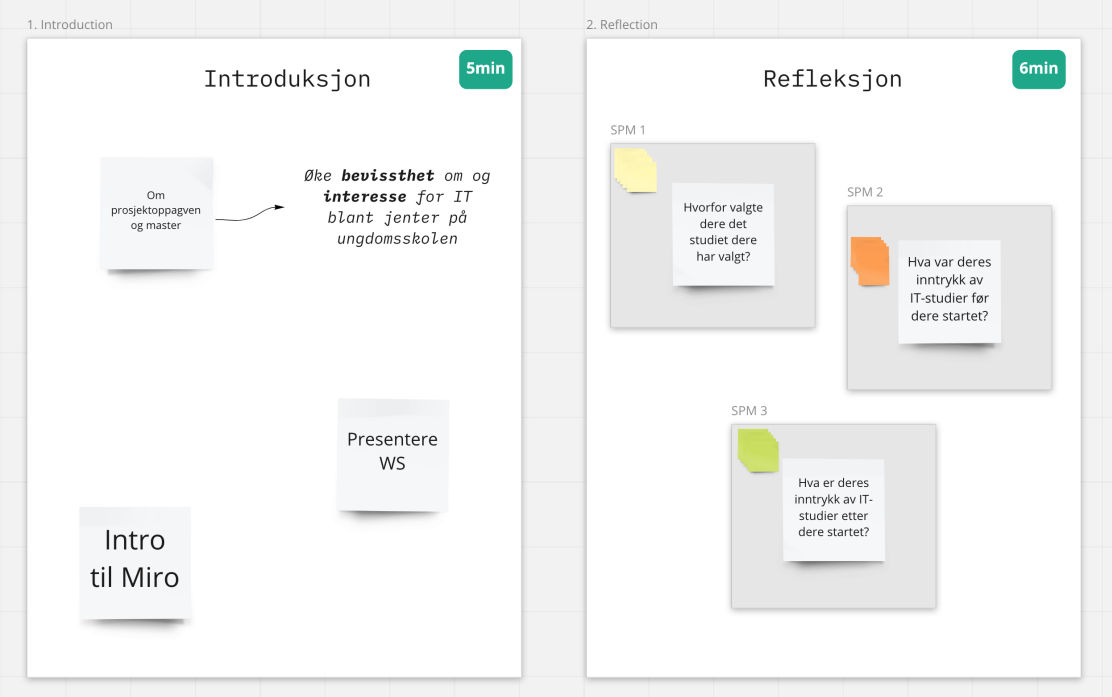


Figure 5.2: The Introduction and Reflection phase in the Workshop.

Dots

Another asset used in the workshop is *Dots*. The dots are color-coded; each participant has their own color. The dots can be dragged around, and each dot represents a vote in the workshop. The dots are illustrated in Figure 5.3, where the three different dots overlapping on the left side with the names adjacent to them is used to remind the players of which color belongs to them.

Timer

Miro has a built-in countdown timer that is utilized in the workshop. Both facilitators can set up and start a countdown. This timer will then be seen by all participants on the board in real-time. An illustration of the timer is in Figure 5.4.

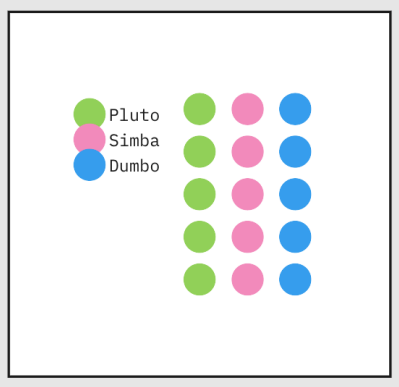


Figure 5.3: The dots used for voting

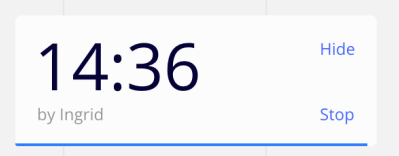


Figure 5.4: The timer in Miro

Learning Goals

As described in Section 5.1, the main aim of the workshop is for the authors to get suggestions for different minigame ideas by having the workshop participants combine learning goals and minigame templates. The learning goals used in the workshop are shown in Figure 5.5. In the workshop, *Game goals* were used instead of *Learning goals* to prevent the participants from getting confused by the learning aspect. The learning goal labels can be dragged to a designated minigame template to illustrate which learning goal the minigame idea supports. The different learning goals are described in detail in Section 2.1.

Figure 5.5: The learning goals

Minigame Templates

The workshop is highly based on the participants using minigame templates to create minigame ideas. In this research, the authors will refer to *minigame template* when the template is unchanged, as shown in Figure 5.6. The green numbered label in the figure is used to refer to the different minigame templates and is removed

after the participants have completed the ideation phase. *Minigame idea* will be referred to when a participant has combined a minigame template with a learning goal and further added content like text and images to it.

The minigame templates used in the workshop are designed by the authors, with inspiration from the available minigames in Attensi. The different types of minigames are described by referring to the number of the minigame templates equivalent to the labels in Figure 5.6. Some minigame templates available in Attensi were omitted as they were too complicated to include in the workshop.

This list gives a short explanation of the twelve different minigame templates, illustrated in Figure 5.6:

1. Multiple Choice Text: A question with different answer options
2. Ranking: Sort the options in the correct order
3. Info: Information for the player that does not require any interaction
4. Multiple Choice Images: A question with different answer options using images
5. True or False: Present a statement, which is either true or false
6. Swipe: Swipe alternatives to the correct side
7. Bubbles: Pop the bubbles that have the correct answers
8. Dialogue: Create a dialogue to simulate interactions with a range of avatars
9. Connect: Connect cards on the left side to the correct card on the right. Can be used with images or text
10. Text Input: Answer the question by typing a word
11. Number Input: Answer the question by typing a number of a given length
12. Blanks: Fill in missing words in a sentence

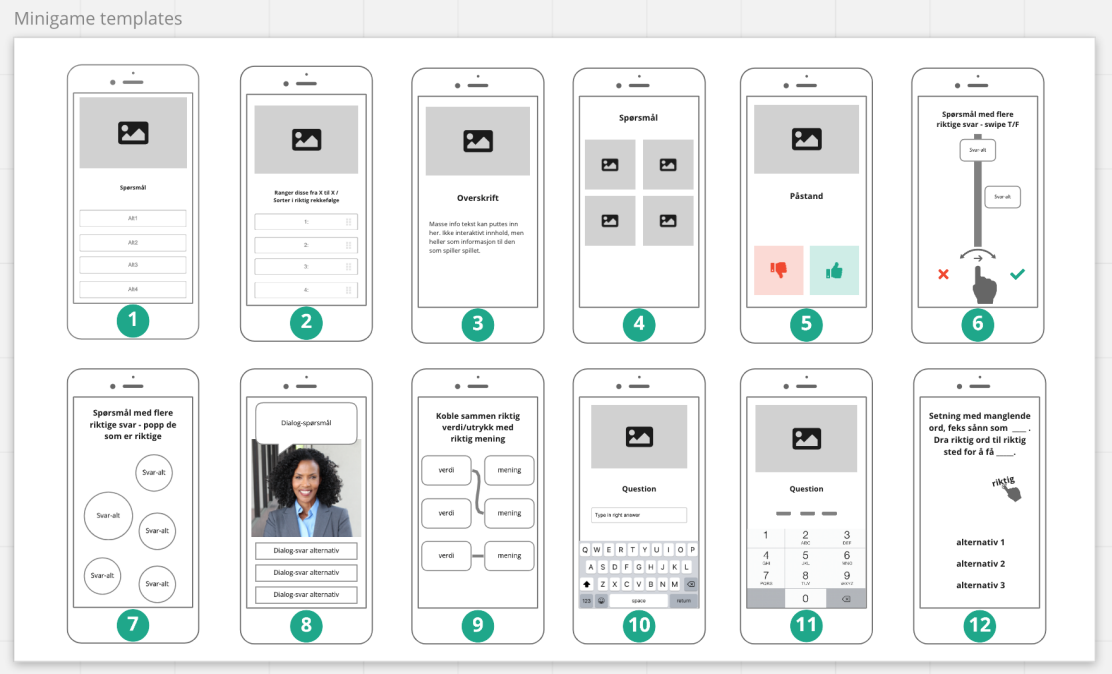


Figure 5.6: The minigame templates used in the workshop.

5.3.2 Phase 1: Introduction

At the beginning of the workshop, the facilitators will introduce the project, which will last for approximately five minutes. The frame used in this phase is shown in Figure 5.2. The previous work and the plan for the Master's Thesis will be presented. Further, the outline of the workshop is described before Miro is introduced. Lastly, the participants' rights are repeated, and they are given chance to ask questions before the next phase begins. To secure the participants' anonymity, they will be assigned aliases that the facilitators will use to address the participants throughout the workshop. In addition, some of the work areas have aliases written on them to mark where each participant should work. The aliases used in this workshop are Dumbo, Simba, and Pluto, all inspired from Disney-characters[2].

[2] `https://characters.disney.com/`

5.3.3 Phase 2: Reflection

A reflection part is included to get the participants into the right mindset and prepare them for the next phase. This phase will last for around 6 minutes. In this phase, the participants will be asked quite open questions about the topic. Triggering the participants' mindset is more important than their actual answers in this part. "What was your impression of ICT-studies before you started studying it?" is an example of questions asked. The frame used in the Reflection phase is shown in Figure 5.2.

5.3.4 Phase 3: Ideation

The Ideation phase has a twofold purpose: to promote creativity and give the participants an introduction to designing minigame ideas. In this part, the participants will work as a team, as they randomly draw one learning goal and one minigame template out of the available ones in the phase 3 Assets frame. The participant's task is to combine the two and create the game content, in other words: the minigame idea. Even though they will collaborate on designing the games, they will take turns filling in the content into the template. This is done to ensure that each participant has tested out how to use the whiteboard and make them more comfortable with the following phases. This phase will last for around 15 minutes, where 5 minutes are used to introduce the learning goals and the minigame templates, and the rest is used for the minigame idea creation. The frame used in the Ideation phase is shown in Figure 5.7. The three white boxes on the bottom are where each participant is filling in the game ideas.

5.3.5 Phase 4: Creation

In Phase 4, Creation, the participants will work individually. The task is to combine each of the learning goals with a minigame template of their choice to design a minigame idea that supports the goal. For instance, if a participant works with the learning goal Provide Role Models and chooses the Dialogue minigame template

(number 8), the participant can doodle an example of an appropriate dialogue for providing role models and come with suggestions for the appearance of the avatar in the template.

The frame used in phase 4 is shown in Figure 5.8. This frame describes the task and the available assets. Each participant will design one minigame for each learning goal, in addition to two minigames that support two learning goals of their choice. In total, each of the participants will create six minigame ideas.

Each participant is given their own assets and work areas, as shown in Figure 5.9. This frame shows the work area of one of the participants. The blue frame contains the participants' assets, while the gray frame is where the minigame ideas are created. From the pilot workshop, described in Section 5.4, some changes on the assets and the creation area in this task were made, described in Section 5.4 Each participant has unique orders of minigame templates within the assets frame, as well as a unique order of the learning goals in the work area.

The participants are given 20 minutes to complete the task, and the timer described in Section 5.3.1 is used. In addition, the facilitators will remind the participants when they are halfway to minimize the risk of not completing all of the minigame ideas.

5.3.6 Phase 5: Dot-voting

After the previous phase, each of the participants' minigame ideas is copied to a shared idea area in the Dot-voting phase. In this area, the ideas are sorted according to their learning goal to prepare for the dot-voting. The participants get 10 minutes in this phase. The frame used in the dot-voting phase is illustrated in Figure 5.10.

Dot-voting is utilized to see a pattern in which ideas and learning goals are favored. This is a concept that is widely used in Design Thinking and Sprints to secure a democratic voting process, which increases the chance of choosing the most suitable idea (Knapp et al., 2016). Dot-voting is conducted by giving each of the

participants 9 dots in total, where one dot is equal to one vote. They are not allowed to place multiple dots on one minigame idea in this phase. For each of the learning goal areas, they are going to place two dots on the designs they think will increase the awareness and interest in ICT the most. In addition, they have one arbitrary dot they can place wherever they want. By having an arbitrary dot, the authors can get an indication of what learning goals the participants think can increase girls' awareness and interest in ICT.

After the participants are finished dot-voting, the minigame ideas within each learning goal with the most dots are transferred to the next step. Among the remaining minigame ideas, the two with the most dots are also transferred to the next step. In total, six minigame ideas are transferred to the Iteration phase.

5.3.7 Phase 6: Iteration

In Phase 6, Iteration, the participants will propose improvements and changes to the minigame ideas from phase 5. The Iteration frame is illustrated in Figure 5.11 and contains the task description, an overview of the game design guidelines, and six white boxes representing the work area. Each of the six white boxes will include one of the minigame ideas from the previous step. The participants will be assigned a fixed starting point according to their alias. Pluto starts at game 1, Simba on game 3, and Dumbo on game 5.

For inspiration to the improvements and suggestions, the game design guidelines are provided. These are explained and work as a tool for the participants to use if they need some inspiration.

The participants get 90 seconds to propose improvements and suggestions on each minigame idea. The proposals should be written on post-its next to the existing minigame ideas and can contain suggestions related to the images, text, learning goal, or minigame template. The participants shall use the post-its with the same color as the dots used in the previous step. A reminder of which color each participant has is placed in the middle of the board. The participants will rotate to the next minigame idea every 90 seconds by following the arrows. The timer is

used in every step to keep track of the time. The rotation is done five times until all participants have worked on all minigame ideas.

5.3.8 Phase 7: Dot-voting with Modifications

After the iteration is done, the minigame ideas and the post-its with suggestions are copied to the *Dot-voting with modifications* frame, shown in Figure 5.12. The frame contains the task description, five dots for each person, and clear space where the minigame ideas should be copied into. This step should last for no more than 5 minutes.

In this dot-voting step, the participants can vote for both minigame ideas and suggestions by placing a dot on the original wireframe and on the suggestions. In contrast to the last dot-voting, the participants are allowed to put multiple dots in the same place, which will weigh their vote. The participants are given five dots each.

The participants are reminded that they should vote for the idea they think best could increase girls' interest and awareness about ICT. In addition, when the voting is done, it is emphasized that there are no winning or losing minigame ideas in this workshop. Everything the participants are producing will increase the authors' insight into the problem, and the dot-votings will help understand which templates, learning goals, and ideas are the most suitable.

5.3.9 Phase 8: Evaluation and Wrap-up

The eighth and last phase is the Evaluation phase. This phase aims to get feedback about the workshop and other input related to the problem, in addition to thanking the participants for their participation. Figure Figure 5.13 shows the Evaluation frame. It contains three different questions, where the participants can drag post-its around the questions to answer them.

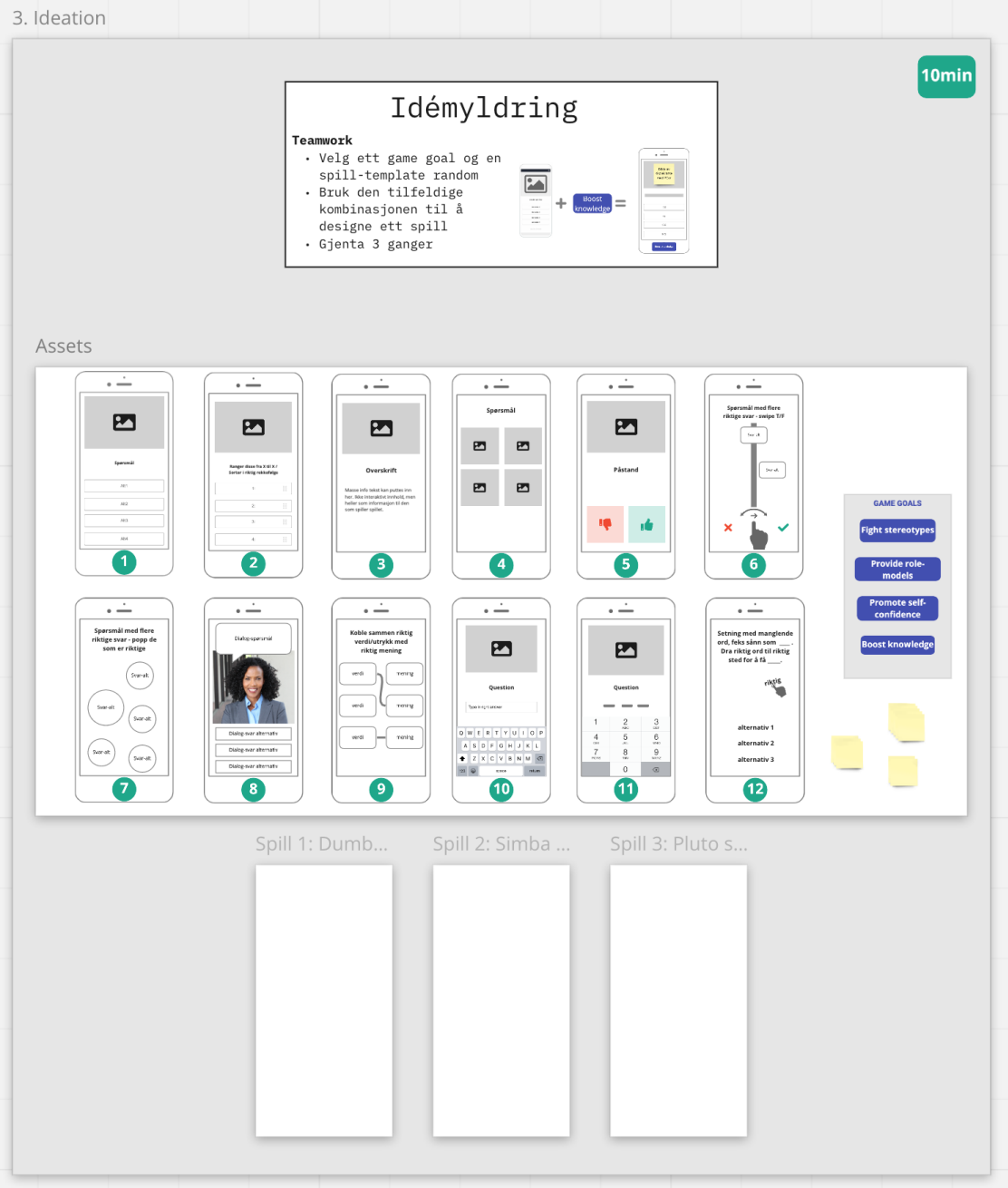


Figure 5.7: The frame used in Phase 3: Ideation

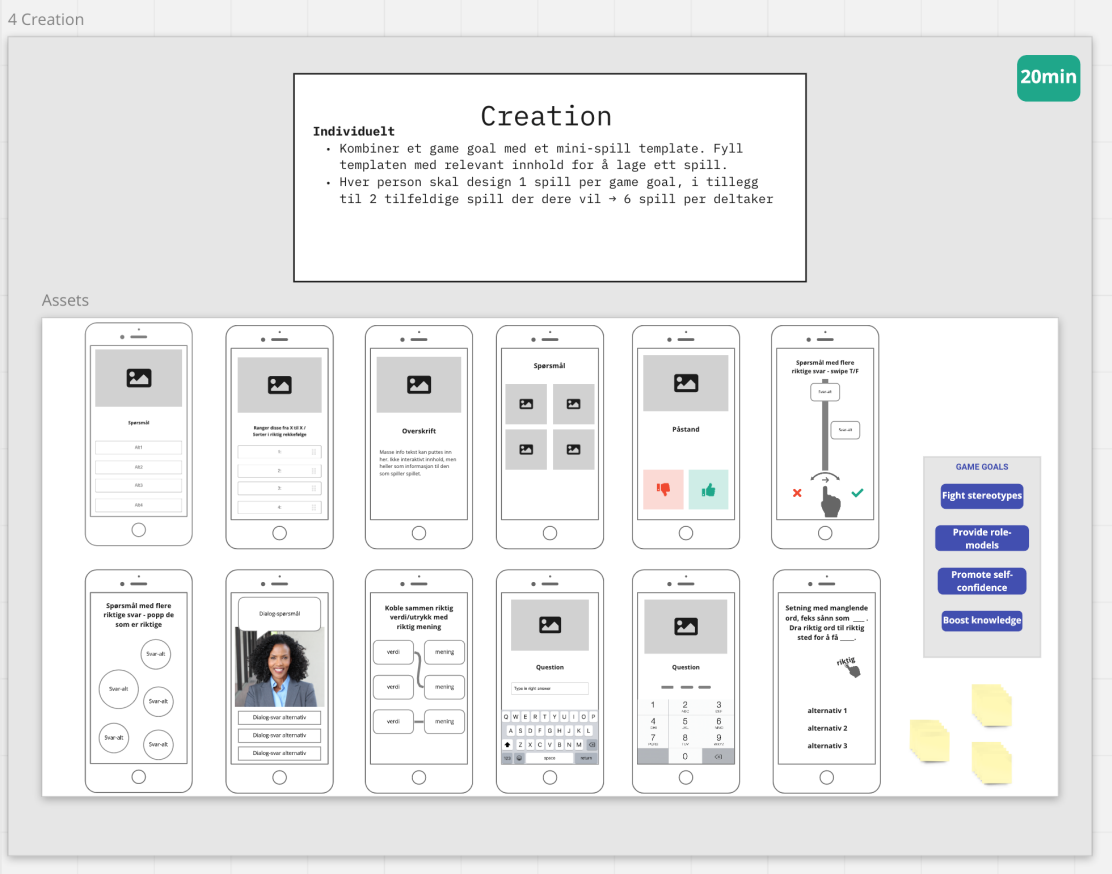


Figure 5.8: The frame used in Phase 4: Creation

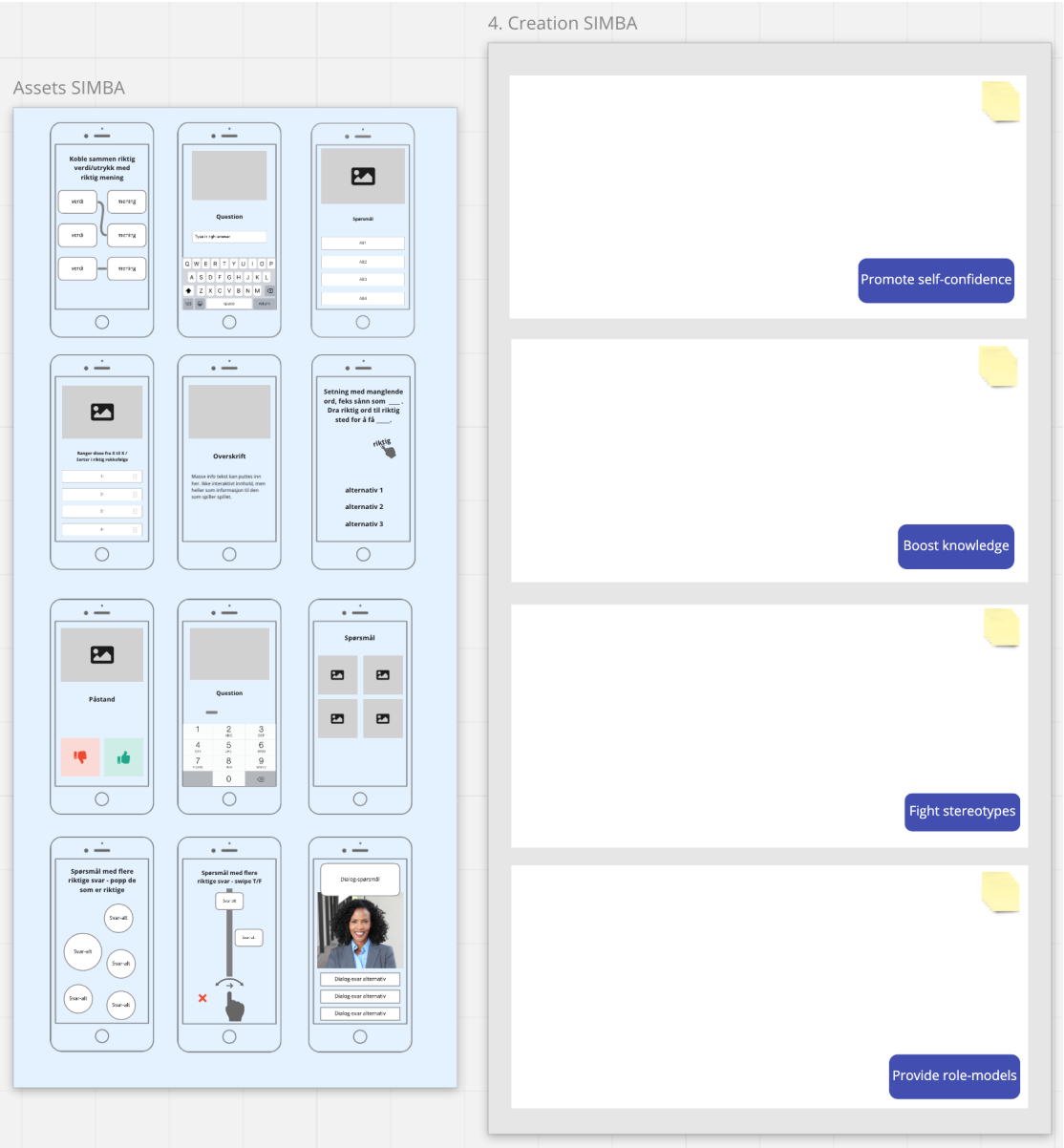


Figure 5.9: An example of a work area used in Phase 4.

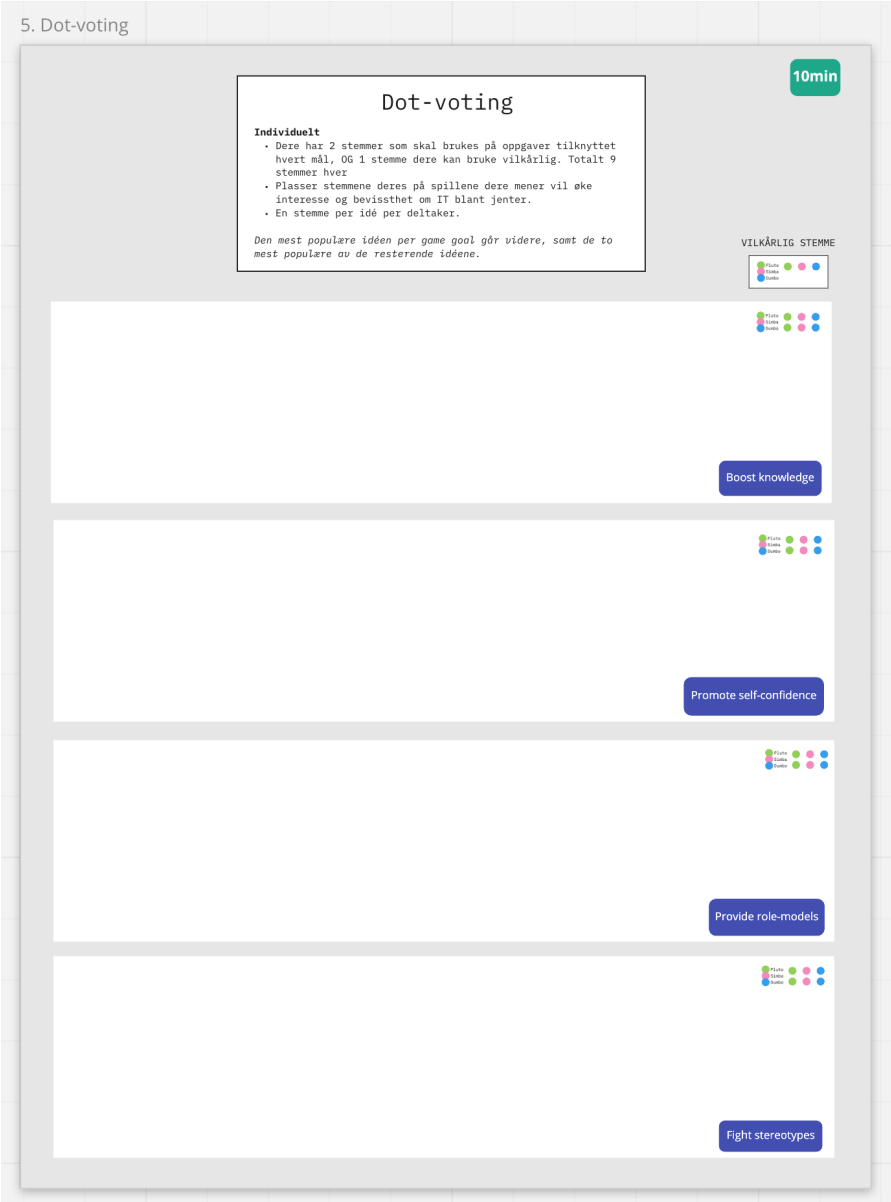


Figure 5.10: The frame in Phase 5: Dot-voting

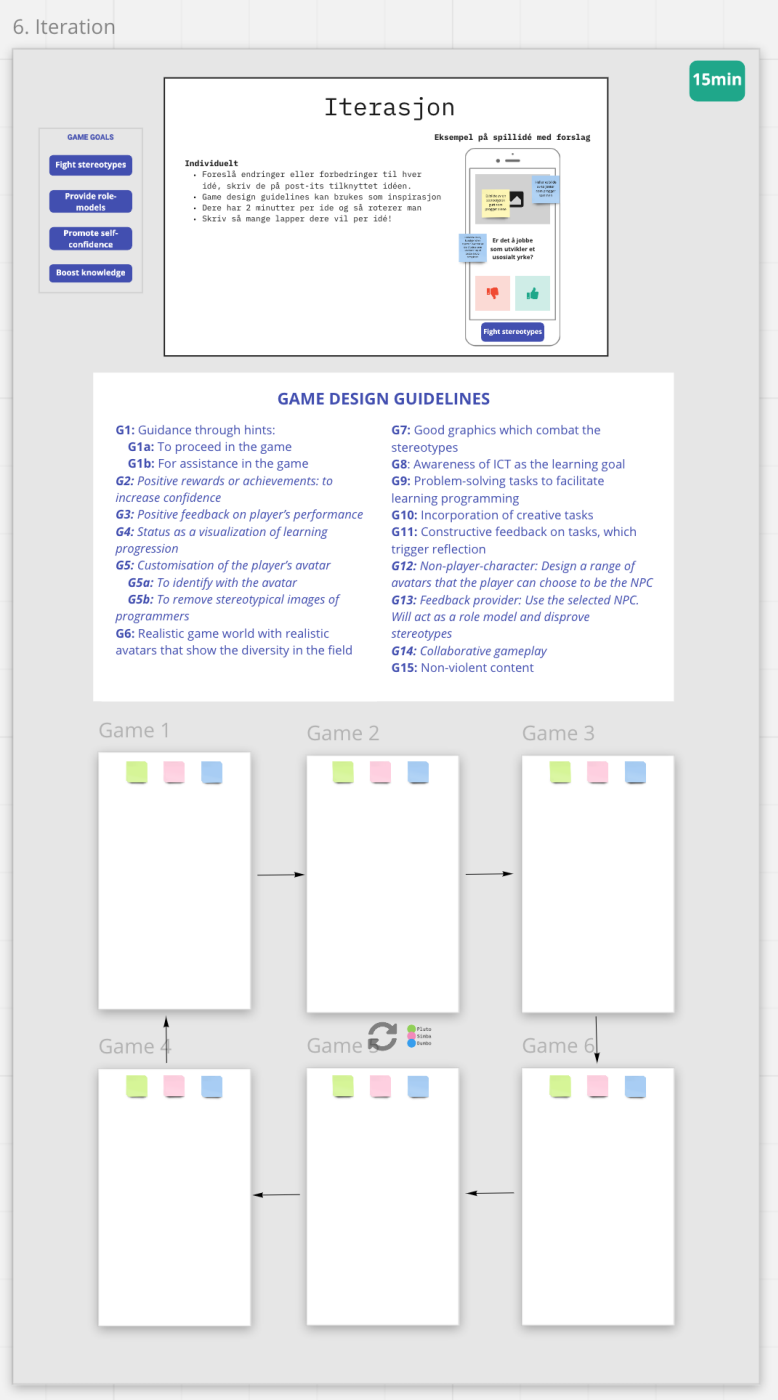


Figure 5.11: The frame used for Phase 6: Iteration

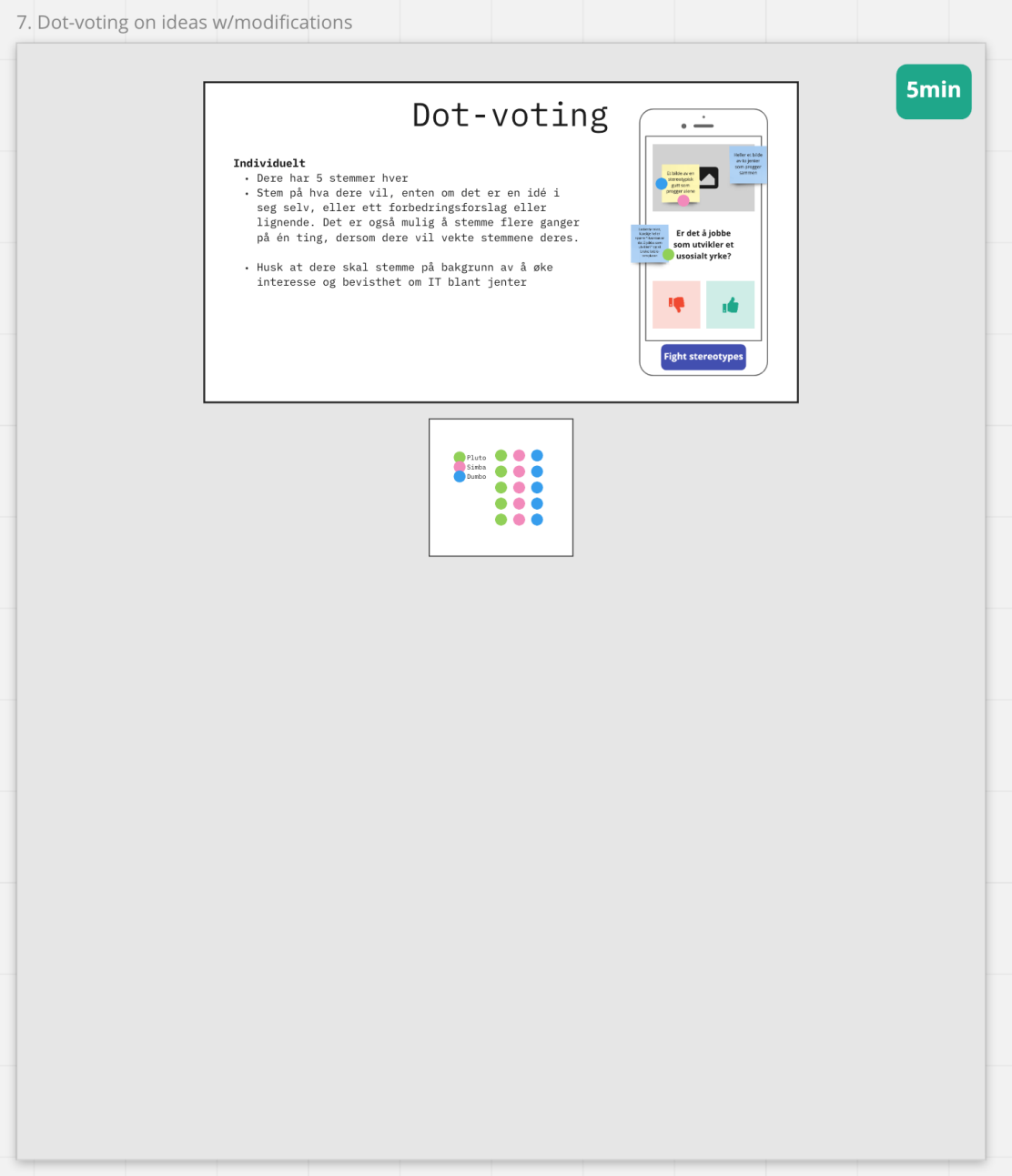


Figure 5.12: The frame used for Phase 7: Dot-voting with Modifications.

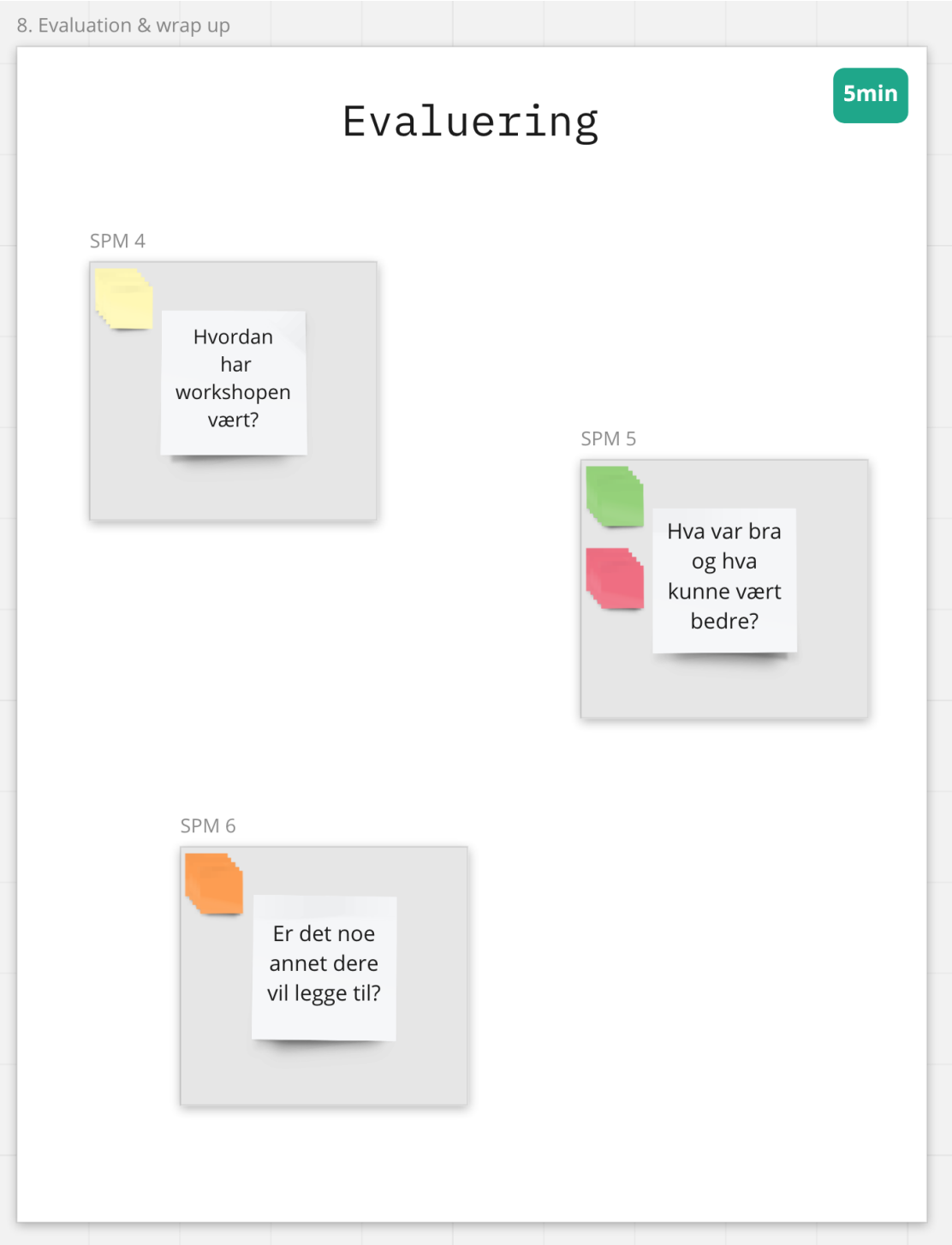


Figure 5.13: The frame for Phase 8: Evaluation

5.4 Pilot Workshop

In order to test the design of the workshop before it is conducted, a pilot workshop is held. The pilot workshop is a simplified version of the workshop, where both the scope and the duration are downsized. The pilot workshop should take 30 minutes to complete, followed by a feedback session on the design by the participants. Having a pilot workshop can help discover technical flaws and inconsistencies in the design. As the workshop is designed with strict time limits, it is crucial that the pilot workshop discovers anything that might interrupt the flow of the workshop.

The purpose of the pilot workshop is to discover points for improvements, check if the time estimates are reasonable, and ensure that the assets and frames created in Miro are understandable for the participants. The workshop consists of copy/paste of used assets from the previous step, so testing this functionality was a focus area during the pilot. Additionally, the pilot test of the workshop aims to check which information the participants need prior to the tasks to understand the concepts.

The participants in this workshop were recruited through the authors' own network. The data collection was observations made by the authors and some feedback from the participants in the end. The pilot test was held through Zoom and by using Miro.

5.4.1 Observations and Feedback

After the workshop, the participants gave feedback on what was good and what could be improved with the pilot workshop. The feedback disclosed issues regarding the information given and some technical issues with the workshop design in Miro. Additionally, the authors observed some difficulties with the workshop design that could be improved.

Technical Challenges

During the pilot workshop, there were some technical difficulties. Some assets were not grouped together in the right way, so when the participants tried to move assets around from one step to another, some parts were not connected properly and were not moved. Even though the participants had used Miro before, they stated that they moved the wrong asset too many times, and that was frustrating. Additionally, the dots were placed behind the tasks they were voting for in the dot-voting steps, so the dots got hidden. Thus, the facilitators must configure the workshop board prior to the workshop by grouping objects and use the correct placement.

Additionally, a problem related to the colors of the dots and post-its in the iteration-phase was discovered. Some of the post-it stacks and dots had very low contrast and almost the same color. Hence it was hard to see the dots when placed on the post-its. This is shown in Figure 5.14. Therefore, the color of the post-its was changed to a lighter version of the dots. In addition, the authors chose to have three different stacks of post-its next to each game, where the participants should choose the ones matching their dot-color. This change is done to be able to see patterns in participants' suggestions.

It was discovered that one participant, who had a Windows computer, struggled to zoom in and out on the Miro board. Instead of using the scroll function on the trackpad on the computer, manual zooming through the buttons in the bottom right corner of the Miro board was used. It was also discovered that there is a function in Miro where one can follow another one's cursor, which worked fine. In that way, the ones who are following one other's cursor are automatically seeing that person's board view. Thus, participants advised the facilitators to instruct other participants to do this if they have a Windows computer.

Information

The participants were familiar with the use of Miro as a digital whiteboard. However, they suggested that if they were not, they would have liked a more thorough

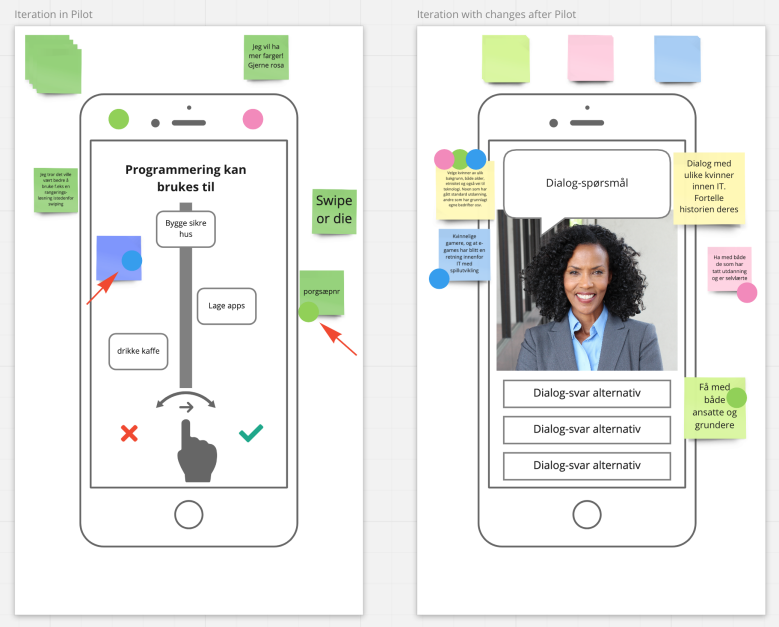


Figure 5.14: Dots and post-its in Iteration-phase before and after changes.

introduction of the tool and how to navigate on the board. Additionally, information about zooming using a Windows computer will be added in the introduction, as that was observed as a technical challenge.

The participants wanted to get more information about the project before they started. For instance, information about the target group was requested, as that would make the creation of games easier. This will be added to Phase 1.

5.4.2 Design Changes made after the Workshop

The suggested changes regarding the design of the workshop are presented in this section. Changes were made both to ensure that time limits are held and the presentation of tasks was clear.

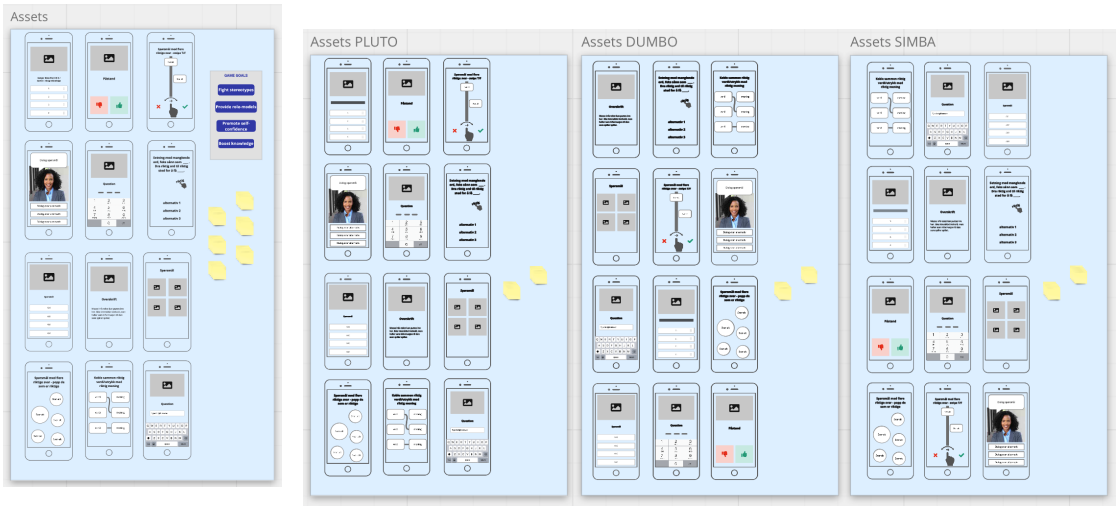
Time

The participants used approximately 3 minutes to create one minigame idea. They stated that it was a bit difficult to create many tasks in a short time. As the total time for the workshop was already maximized, the task in phase 4, Creation, was instead downsized. Thus, it was decided to limit the creation of games from 8 per person to 6 games per person in phase 4, Creation. Then, the total number of games in phase 5, Dot-voting, will be 18, not 24, as planned. Thus, the number of arbitrary dots per person was reduced from two to one per person.

Tasks

It was observed that both participants chose to use the same minigame template. When they were asked why, they said that they chose to use one of the closest templates in regards to their working area. Thus, a randomization of the minigame templates was suggested to ensure that the participants use a wider specter of the templates. The assets before and after the changes can be seen in Figure 5.15a and 5.15b. As one can see, the first design contains only one asset frame, as all participants had identical asset frames. After the changes, the participants had different asset frames. Thus Figure 5.15b shows three different asset frames.

The same thing was observed with the learning goals, so randomization of the order of the learning goals for each participant was suggested. Additionally, it was observed that the post-it notes in the asset-frame in phase 4 were too far away from the creation board, and the post-its were moved onto the board to make it easier for the participants. The changes are shown in Figure 5.16, where the first design of the creation board is in Figure 5.16a, and the final design of the creation boards are in Figure 5.16b. As for the assets, the participants have different creation boards in the improved design.



(a) The assets before changes

(b) The assets after changes

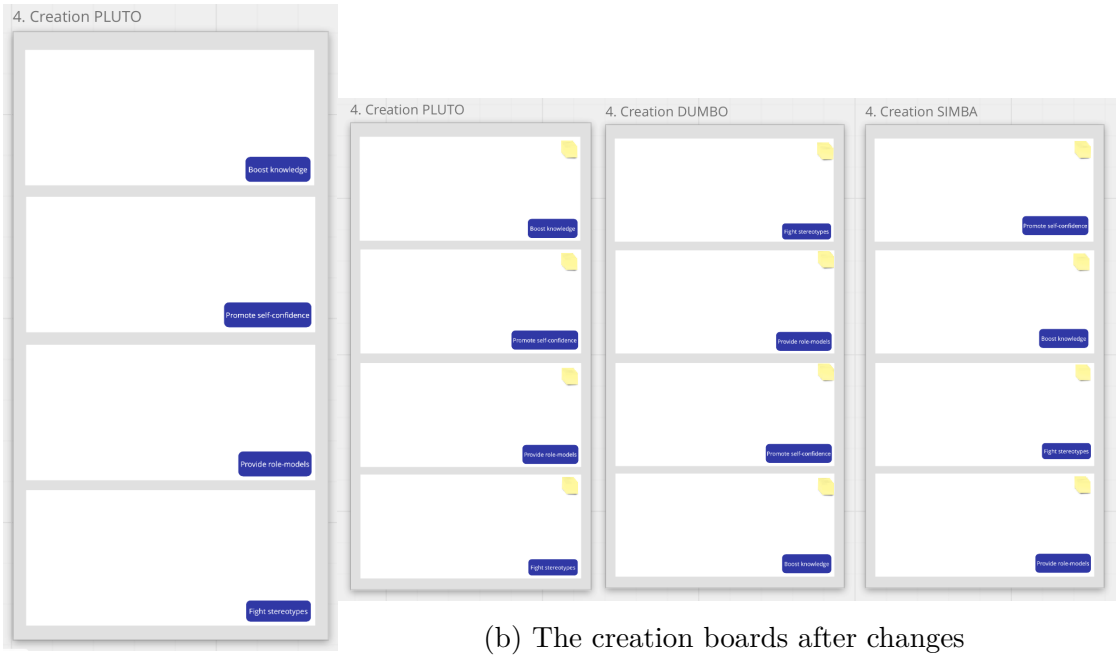
Figure 5.15: Assets before and after changes

5.5 Workshop with Female Students

After the co-design workshop was created and a pilot workshop was held, the workshop was conducted with the participants. As mentioned in Section 5.1, the main purpose of the workshop is to generate different minigame ideas to increase the awareness and interest in ICT among female secondary students. In this section, the participants and process of the co-design workshop are presented. Further, the observations gathered during the workshop are described in Section 5.5.3, and the results are presented in Section 5.5.4. Lastly, the results, the method, and the tool used are discussed in Section 5.5.5.

5.5.1 Participants

Nine participants were recruited to participate in the co-design workshop. The participants were recruited through the authors' network at Norwegian University of Science and Technology (NTNU). The authors asked female students that studied technology studies to participate. The participants were chosen because they might



(a) The creation board before changes

(b) The creation boards after changes

Figure 5.16: The creation boards before and after changes

have experienced the gender gap in ICT themselves, and based on that, they might have interesting thoughts and ideas regarding the problem addressed in this research. Additionally, as the participants study technology, they can possibly use their own experience regarding what made them interested in technology and ICT to create compelling minigame ideas that might increase awareness of and interest in ICT. The participants signed a consent form (Appendix D.2) before participating in the workshop.

5.5.2 Process

The participants were separated into three groups, A, B, and C, to fit the workshop's design, and each group conducted the workshop in their own session. The division into groups was also made to ensure their anonymity when the groups are referred to in the results. The participants received compensation, a 200 NOK gift card,

which could be used in multiple stores, for their involvement. There were held three workshop sessions over two days. Each workshop lasted 90 minutes and where held digitally over Zoom. The audio was recorded using Zoom's built-in recording function. This was done to capture information in conversations during the workshop, which might not be reflected in the workshop results.

The workshop tasks were conducted using Miro, where every participant opened the workshop board on their own computer and interacted individually through the software. The facilitators participated together from the same place and presented the workshop by following a predefined workshop guide created before the workshop. This workshop guide consisted of which information to be mentioned in the phases, what to remember to do during the workshop, and the time limits for each phase. The workshop guide was created to ensure that all workshop sessions were consistent and that all participants got the same information during the session.

5.5.3 Observations

The facilitators observed some differences between the three groups.

The workshop conducted with Group A lasted 15 minutes over the expected time. This was due to some technical problems. The participants in Group A were quite open-minded and had an open and eager discussion during the reflection-phase.

Group B was three girls working in The Girl Project Ada. This is a project which aims to recruit girls to technology studies at NTNU. Therefore, the participants from this group had background knowledge and previous experience with the problem. This was evident in the minigame ideas from this group: they were comprehensive, complex, and unique.

Two of the participants in Group C sat next to each other during the workshop. The facilitators suggest that this might have some impact on the conduction of the workshop. This was especially evident in the amount of discussion done between the participants. The facilitators could see the two sitting together were speaking a bit with each other, but they muted themselves, even when they were told to

have their microphone on. Therefore, there was almost no dialogue between the three participants.

During Group A's and B's workshop, the first round of dot-votings ended with a tie between some of the games. Thus, the facilitators asked the participants to decide on a winner by discussing with each other. This could have had some implications for the result, but the authors argue that this was a better way than choosing randomly. The facilitators observed that the participants also took the minigame templates and learning goals into account when choosing a game, aiming for a wide variety of games.

Feedback from Participants

In the Evaluation-phase, the participants were asked to evaluate the workshop, and both positive and constructive feedback was encouraged. The facilitators got several positive notes regarding the setup of the workshop in Miro, questions, and the explanation of tasks. Note that the post-its are translated from Norwegian to English. For instance, one post-it was "Good explanation of the tasks, both on why and how they should be completed." This indicates that the results are trustworthy as it seems like the participants understood the tasks correctly. Further, several bragged about Miro and thought it worked very well to conduct the workshop online using that collaboration tool. In fact, one of the post-its said, "Coolest workshop I have attended digitally." However, one of the post-its mentioned that it was hard to move the dots around at times.

There was also a lot of praise given related to the iteration- and dot-voting-phase. Some said it was good that one could improve the minigame ideas throughout the workshop in an iterative approach. In addition, some thought it was nice to be able to vote on alternatives. Further, some said they appreciated the tight deadlines for the different phases. One said that this gave greater room for brainstorming, and another said it made one come up with ideas quickly without thinking too much. However, one gave a negative note saying it was too much time pressure at times.

The most frequently mentioned improvement, written on five different notes, was related to the wish for more discussion. They wanted more discussion and more brainstorming than what they experienced. Some notes argued that this would make them able to work on ideas together and that they would get more opportunities to present their ideas. One also wrote that it might have helped the ideation process to discuss more with each other, but that this also could lead to that one might be affected by others' ideas. This is something that should be taken into consideration if the workshop is held again. The authors were aware that this might become a problem, but discussions were held to a minimum due to the time limit. The time limit was set to 90 minutes since it is hard for the participants to focus for a long time in a digital workshop. If this workshop is conducted physically in the future, the authors recommend that the facilitators expand the workshop by around 30 minutes to make room for discussion.

5.5.4 Results

The workshop results are considered complete from all three workshop sessions, meaning that all participants managed to finish the tasks within the given time limits. In each of the workshop sessions, all participants managed to create six minigame ideas in phase 4, Creation. Accordingly, each session resulted in 18 minigame ideas, and six of them have associated improvements. The minigame ideas with improvements from each workshop session can be seen in Figure 5.17 (Group A), 5.18 (Group B) and in 5.19 (Group C). The minigame ideas are also summarized and briefly described in Table 5.1 and are the results from the workshop. The minigame ideas consist of a learning goal, a minigame template, suggestions for improvements, and dots, which indicate the preferred ideas and suggestions. In addition, some of the minigame ideas have used the game design guidelines.

When the results from each session are combined, there are 18 minigame ideas with associated improvements. Out of the 18 minigame ideas with improvements, 10 of the 12 minigame templates are used. One of the minigame templates, the Dialogue template, is used four times in the resulting minigame ideas, with the connecting learning goals Provide Role Models and Promote Self-confidence.

When we look at the results according to the use of learning goals, each is included in at least four minigame ideas. This is not a surprising result, as the most popular minigame idea from each learning goal in phase 5, Dot-voting, was included in phase 6, Iteration. Thus, a minimum of three minigames per learning goal was expected. Provide Role Models, Promote Self-confidence, and Boost Knowledge are included in four minigame ideas, while Fight Stereotypes is included in six minigame ideas. This might indicate that fighting stereotypes either was more important for the girls or the "easiest" learning goal to create content for, due to the participants' own experiences with stereotypes within ICT. These results are shown in Figure 5.20.

Even though there are 18 resulting minigame ideas with improvements (Figure 5.20), two pairs of minigame ideas are so similar that they are combined into two minigame ideas instead of four. The two pairs are the two minigames ideas with the Dialogue template for Promoting Self-confidence and the two minigame ideas using the Connect template for Boost Knowledge. For this reason, there are 16 minigame ideas with improvements as results. These minigame ideas are the primary results of this workshop. The resulting minigame ideas are the ones that will be the main inspirational source for the next step in this research, namely designing and implementing the serious minigame.

When it comes to the use of the game design guidelines in the results, few of the guidelines are present in the results. The guideline to use hints to proceed in the game (G1) was suggested by group B in one of the Boost Knowledge ideas. Additionally, the guideline to use the Non-player character (NPC) as a role model (G13) is used several times by all groups. Other guidelines are used as well, but not explicitly suggested by the participants, and these are listed in Table 5.1. Further, some guidelines are implicitly implemented in the minigame templates, such as giving positive feedback on the player's performance (G3), which is included in the game elements.

As one can see in the figure covering the results (Figure 5.20), some ideas have been voted for in their entirety, while in other minigame ideas, some post-its or comments are highly voted. In the Group B results, one minigame idea is not voted for. Insights like this will be considered when designing the final minigames.

It is important to note that the results from this workshop were not intended to be finished game concepts or minigame designs but only ideas for the authors to base the design on. However, the results are providing the authors with insight into the possible ideas that can be implemented in the game. The authors will be inspired by the results from this workshop but will not be limited to the minigame ideas designed by the participants. Further, the authors can use their own experience when developing the minigames.

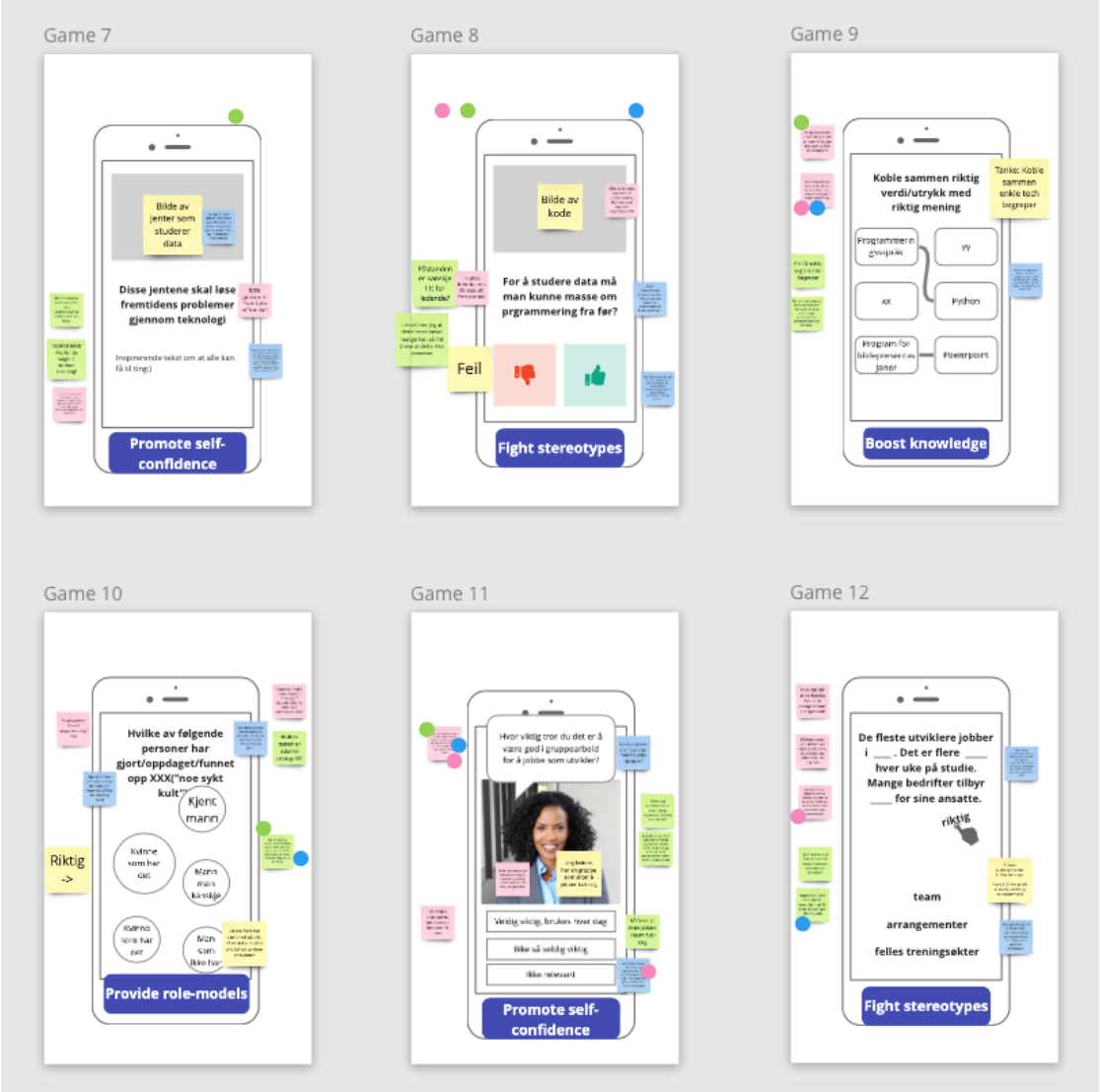


Figure 5.17: Final results from Group A

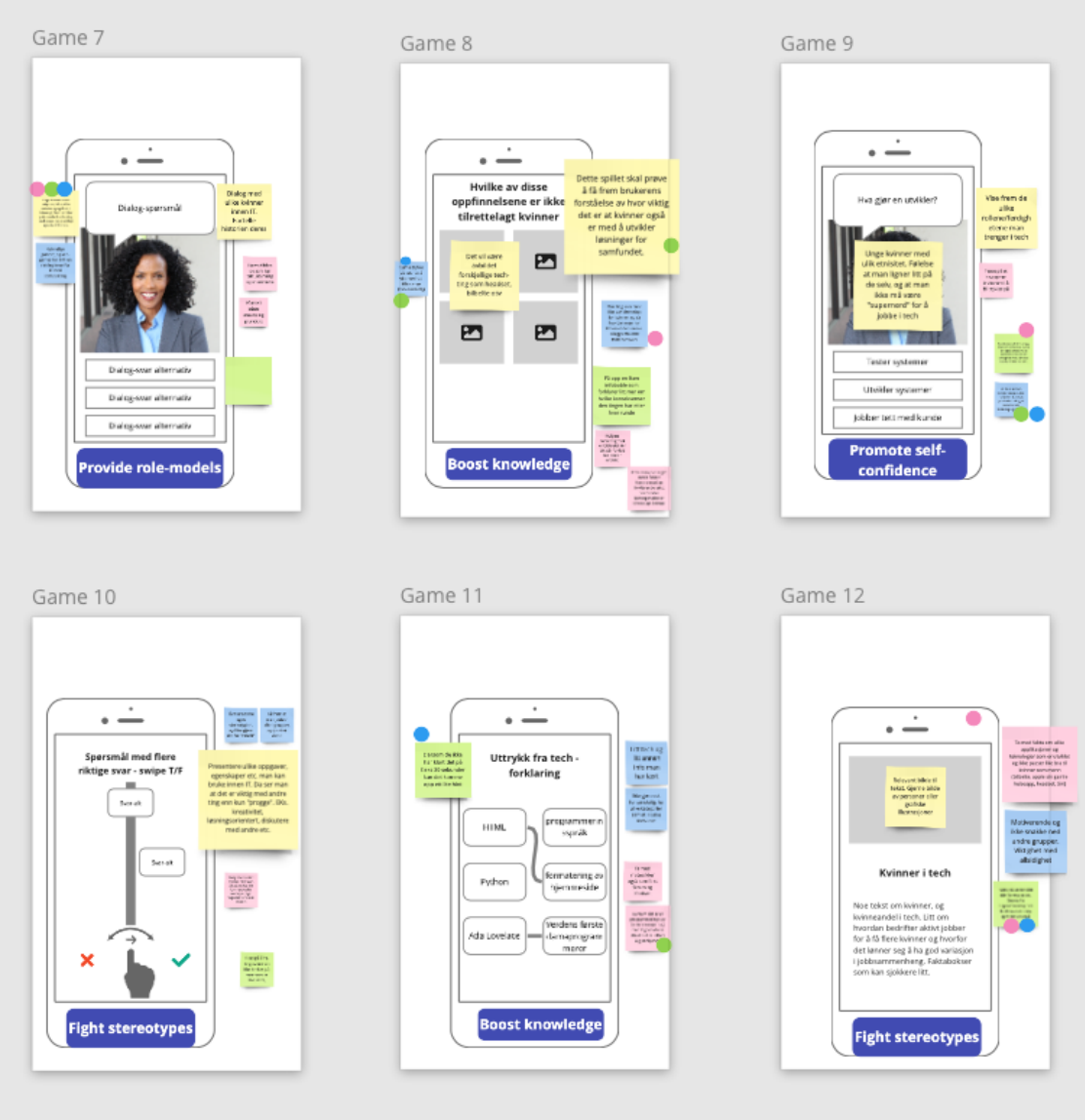


Figure 5.18: Final results from Group B

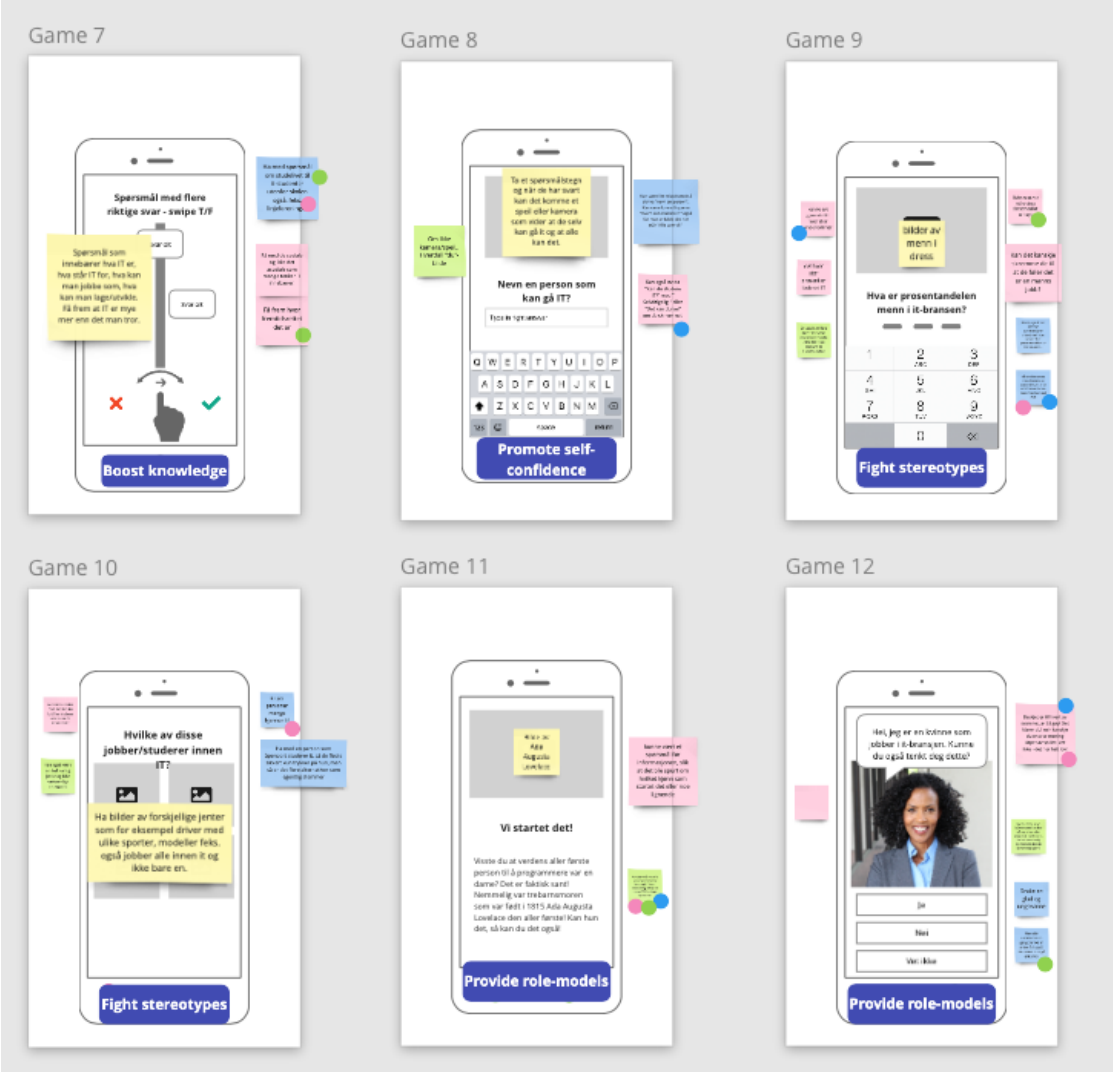


Figure 5.19: Final results from Group C

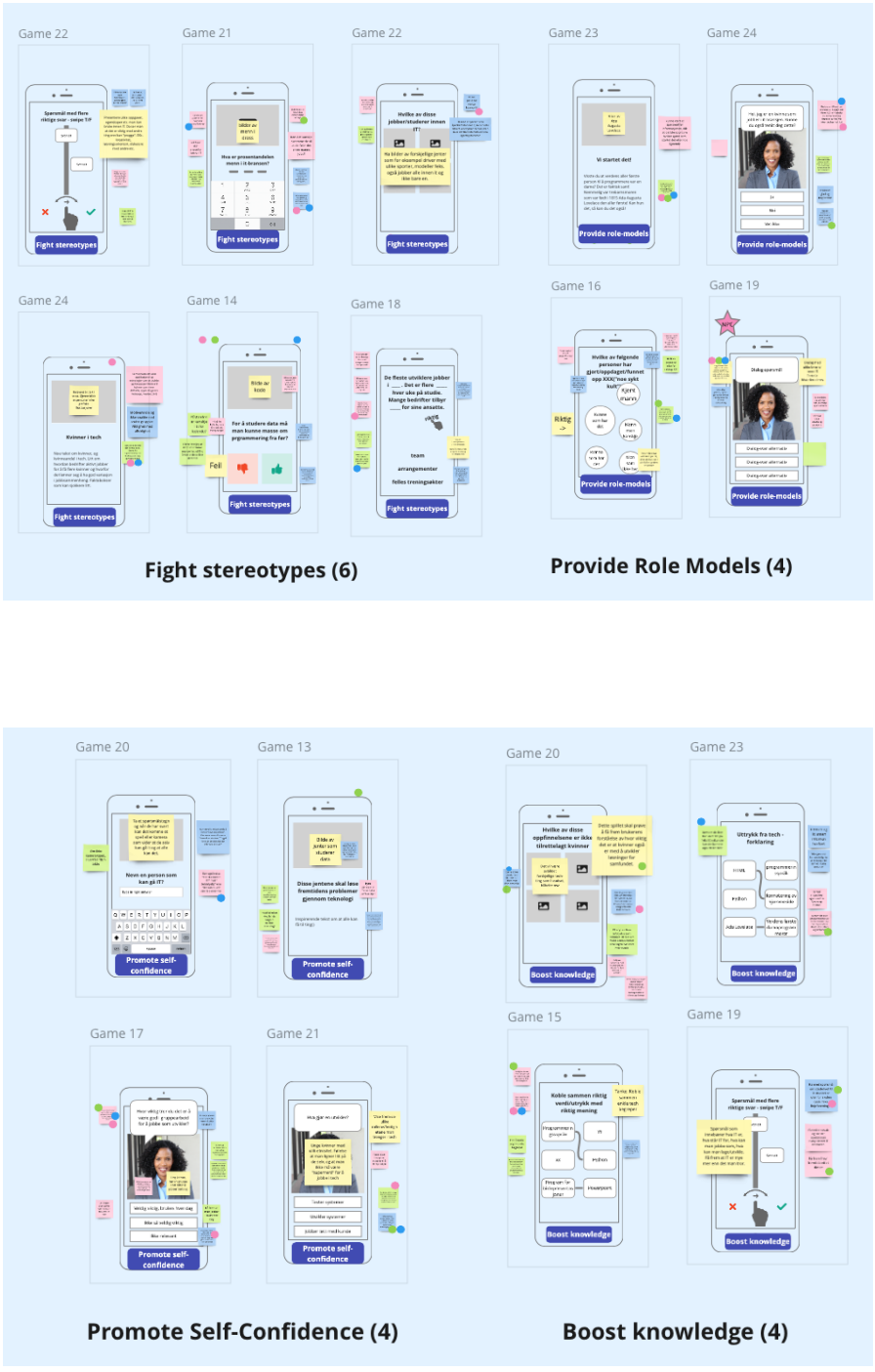


Figure 5.20: Final results sorted according to learning goals

5.5.5 Discussion

Minigame Ideas

The participants were not explicitly told that creating a sequence of connecting tasks was allowed. Thus, no such task was created. However, through a post-it on a Boost Knowledge idea, group B mentioned that an explanation of the answers should be provided after the player has answered in order to provide enough knowledge to the player. Additionally, group C suggested having a minigame before providing plain information about a role model. However, none of these sequences are designed, only suggested to be a combination.

There is also a consistent pattern that few tasks related to Boost Knowledge have very technical content. For instance, there are few tasks related to code comprehension and basic programming concepts. Such tasks require an explanation of the concepts beforehand to facilitate learning and might require a sequence of tasks. One can therefore argue that this is a possible reason why there are few technical tasks. That is a limitation of the results from the workshop, as sequences of tasks could have been a good method for learning programming.

In some of the minigame ideas, the content of the tasks and learning goal is not aligned but fits more to another learning goal. This might be because the participants had a limited understanding of the different learning goals. In other minigame ideas, several learning goals could be appropriate. This will probably be corrected in the final design, given that the minigame idea is interesting.

Additionally, a few of the participants were somewhat concerned about creating too difficult tasks, resulting in simplified minigame ideas to make sure that everyone in the target group will understand the concept. The participants might have been affected by the information they got on beforehand, as they were told that the target group was not expected to have any prior knowledge of ICT. More detailed information about the target group could have helped the ideation and creation of technical tasks related to the learning goal Boost Knowledge.

Further, there were few minigame ideas related to ICT studies. The reason for

this is uncertain, but one reason might be that the participants were students themselves. Their next step in the ICT field is a job, which was the theme of many of the minigame ideas. However, even though the studies were forgotten, some of the post-its in the iteration-phase indicated that more minigame ideas could and should include more about ICT studies. This indication became clear by the number of dot-votings on the suggestions.

Only a subset of the guidelines presented in the iteration-phase was used in the minigame ideas. This might be because they were too overwhelming, unsuitable for the given minigame ideas, or not clear enough. Also, it might be connected to the limited duration of the workshop, which does not give time for the participants to familiarize themselves with the whole set of guidelines. In contrast, one guideline that was used often was **G12**: *Feedback provider: Use the selected NPC. Will act as a role model and disprove stereotypes.* The minigame ideas with the Dialogue template all had post-its suggesting realistic avatars that should represent a broad range of people. However, this might be due to the template's image, which is of a realistic, female avatar, which could be leading.

An interesting discovery was that none chose to make minigame ideas with the Multiple Choice Text (template no. 1) nor the Ranking (template no. 2) templates. The authors thought these templates were going to be chosen most frequently due to their simplicity, especially when creating technical tasks. This might imply that the participants found them boring or just were less preferred. However, this might also be because there was a lack of technical tasks, as mentioned earlier.

Reflection on Method

Even though this workshop gave satisfying results, other workshop designs might foster creativity and idea-generation regarding our problem in the same way. For instance, the Privacy Game Co-Design Workshop used in Saxegaard (2018) could be altered to fit the purpose of our workshop by, among others, changing the focus from privacy to awareness and interest in ICT. This workshop is based on the work in Harteveld (2011), which builds on the idea that you only need three core elements to create a successful serious game. However, this workshop has only be

held physically, which could not be done in this project due to Covid-19. Therefore, alterations and the implementation of a digital version of this workshop would have to be done.

Another possible method could be to do field testing with surveys. The authors could have created different minigame design ideas and ask girls in the target group which ones they prefer. If a decent number of girls were recruited, this might result in a pattern of preferred minigames among the subjects. The field testing would be more relevant to do physically since it is suitable in a classroom setting. Again, Covid-19 made this option unfeasible. The different minigame ideas could also be designed and distributed digitally. Since a pattern only will appear with a decent number of answers, the authors decided not to move forward with this idea since it could be risky if not enough girls were recruited.

Instead of doing field testing, one could also have done the creation of games with girls in the target group, like done in this workshop with girls that are older than the target group. Due to the technical difficulty of using Miro and the lack of knowledge about ICT among young girls, the authors decided to rather include older girls with knowledge about ICT for the workshop.

Miro as a WS Tool

As mentioned, Miro works like a digital whiteboard, where one can configure the board on its own. Either one can use predefined templates or create its own ones. The authors chose to create their own design as there were no predefined templates that were appropriate for the purpose of the workshop. This was a time-taking process, but it was worth it to get the wanted design.

Before one conducts a workshop using Miro, the authors recommend testing the design in some way, as the grouping of objects and locking of frames to specific places on the board can be important for how the participants perceive the tasks. As one of the participants stated in the pilot test, some tasks were "annoying" as the objects were not grouped together, and it was complicated to move everything around. Therefore, to reduce the risk of the participants becoming unwilling to do

the tasks with the best possible effort, it is important to make sure that the Miro board is well-designed and properly structured.

Additionally, all participants in this workshop are age 18-25 years and study technology. Hence one can assume their technological skills are higher than the average person. When having a digital workshop in this format, the technical skills of the participants should be taken into consideration when designing the workshop. Our workshop, with strict time limits and limited time for training, required that the participants were fast learners and had above-average technical skills.

There were few issues related to the implementation of the workshop. One can argue that a reason for that is that the workshop design was properly prepared by the facilitators by ensuring that objects were already grouped and tested many times by the authors. In that way, minimal issues occurred. Additionally, some of the participants had used Miro before.

However, as mentioned in Section 5.5.3, one of the groups used more time than expected due to technical problems. The authors experienced that having both Zoom and Miro running simultaneously was demanding for the computer, which caused lagging. This had negative effects on the facilitators' ability to orient and move objects in Miro. Therefore, copying all the minigame ideas from the creation- and the iteration-phase to the dot-votings demanded more time than expected. After this workshop was conducted, the authors made some changes to the positions of the frames in Miro. These changes would not make any impact on the workshop's outcome, only make the facilitators save time when moving assets between the phases in Miro. Thus, it could be beneficial to conduct a more thorough pilot with various computers and internet connections to secure a problem-free session.

The implementation of the workshop in Miro worked well with groups of three participants. It was sufficient time to ensure that all participants had understood the tasks, as well as to ensure that all were familiar enough with the tool to do tasks individually. Having an online discussion worked well with three participants. They could all talk together without interrupting or leaving one out of the conversation, which is a common issue when discussing together online with several participants.

All in all, the authors argue that Miro works well as a digital workshop tool. However, one must bear in mind that the configuration of boards might be time-consuming and that workshop designs should be tested before being put in use in order to make the best possible experience for the participants and ensure a good result.

Learning goal	Minigame template	Description	Guidelines
Fight Stereotypes	Multiple Choice Images	Which of these work in IT? Picture of a wide range of girls. Suggested to use pictures of persons people are familiar with.	G7: Good graphics which combat the stereotypes
	True or False	"To study computer science, one needs to know programming". To show that one don't need to know it on beforehand	
	Blanks	Text about how the workday for a one in the IT field is. Emphasizes the perks.	
	Info	Info about women in technology. About how companies work to get more women in tech and why it is important	
	Swipe	Present different tasks and skills you need within IT. To show that social skills etc are important	
	Number Input	Type in the percentage of men in the IT-field. Suggested to flip to women and to emphasize that it needs to even out.	
Promote Self-Confidence	Text Input	"Mentioned a person who can study IT". Ment to show that everyone can study. Suggested to have a follow-up text which explains this.	
	Dialogue	"How important do you think being a good team mate is for a developer?". Suggested to show that girls can utilize the knowledge they already have.	
	Dialogue	"What does a developer do?". To show the different roles and skills you need in the technology field. Suggested to emphasizes that one needs different roles and experience, and to ask if one wants to learn more about it, in order to connect it to the learning goal	G6: Realistic game world with realistic avatars that shows the diversity in the field
	Info	"These girls are going to solve the problems of tomorrow with technology". Show a picture of young girls with diversity, and write that everyone can do it	G7: Good graphics which combat the stereotypes
Provide Role Models	Bubbles	"Which persons have invented this?". Have different women as alternatives	
	Dialogue	A dialogue with different women in IT that tells their story.	G13: Feedback provider. Suggested to use women with different background, age, and ethnicity to act as role models.
	Dialogue	"I am a women working in IT, could this be interesting to you?" Suggested to have motivational replies, depending on what the player answer	
	Info	"We started it". Info about Ada Lovelace, the world's first programmer.	
Boost Knowledge	Multiple Choice Images	"Which of these inventions were not designed for women?". To get the player to understand how important it is that women is included in the development of solutions for society. Suggested to include additional info about the inventions	G1: Hints. Suggested to have info button they could press if it gets too difficult
	Connect	Connect the right tech-expressions with the right description of it.	G1: Use of hints. Suggested that hints should appear after 30 seconds.
	Connect	Connect the right tech-expressions with the right description of it. Some suggestions for improvements.	
	Swipe	Have different claims about the IT field, where user has to swipe them to true or false. Emphasize that the IT-field consists of more than people think. Also suggested to have claims related to the study program and to show how future-oriented IT is.	

Table 5.1: Final minigame ideas

6 Implications for Design

The following chapter describes the impact the different processes in this research have had on designing the serious game. Before designing the game, both an interview with a gender expert (Chapter 4) and a co-design workshop (Chapter 5) have been held. These results will be combined to design the game content and the game concept of the serious game. In Section 6.1, the implications from the interview are presented. Section 6.2 describes the results from the co-design workshop that have impacted the final design. In these two sections, some high-level requirements for the serious game will be defined, which are summarized in Section 6.3. The order of the high-level requirements is chronological.

Further, some results from the interview and the workshop have been excluded from the design, discussed in Section 6.4. This section also includes a reflection on the platform which will be used to implement the serious game. Lastly, the first prototype of the game is described in Section 6.5.

6.1 Gender Expert Interview

The results from the interview with the gender expert that impact the design involved four themes: Games in the context of gender diversity, the learning goals, the game design guidelines, and the game activity.

In general, the game will be developed based on including everyone, as the whole Information and Communication Technology (ICT)-community should be a safe space for everybody, as the gender expert pointed out. Additionally, the game's purpose will be emphasized and permeate the serious game. Thus, the game should

give the player a clear overview of the learning goals (**HR01**). The gender expert mentioned some examples that could be interesting to present, and some of these will be used for inspiration when creating additional minigames than the ones from the workshop.

Regarding the learning goals, the gender expert mentioned that self-confidence should be promoted through fighting stereotypes. Thus, it is decided that the modules Fight Stereotypes and Promote Self-confidence should be consecutively in the game. Providing Role Models will be highly prioritized, while Boost Knowledge will have a lower priority but still be included in the game. Gendered labels and metaphors will be avoided (**HR02**). Additionally, the minigame content related to fighting stereotypes will be chosen wisely to prevent the risk of reinforcing the stereotypes.

The gender expert had clear thoughts regarding the game design guidelines and was very positive about having awareness of ICT as the learning goal. As already mentioned in earlier chapters, this is already decided, and awareness of and interest in ICT will be the overall learning objective of the game (**HR03**). There will be incorporated creative tasks in the serious game (**HR04**) if it is possible. Additionally, constructive feedback will be included, but it will be brief and straightforward (**HR05**) after advice from the gender expert.

Sexualization will be avoided (**HR06**), and if there are avatars in the game, customization will be implemented in order to be able to express individuality. The gender expert explained that avatars and metaphors were crucial to making right since they could work against its purpose. Thus, avatars and metaphors will most likely be omitted to ensure that the outcome is as intended.

Before, during, and after the game activity, the gender expert advised monitoring the players (**HR07**). While the participants play the game, they will be observed by the researchers. Monitoring will be done so that the players' results, scores, and level of completeness will be saved. Such monitoring is already available for use in Attensi. There will not be done monitoring before or after they play the game. The gender expert advised targeting children in the age of 11-12 years. However, this age group will not be included in this research. There are several reasons, but

mainly because the background for this research revolves around the research on teenagers. It could be worth noting for further work that targeting 11-12-year old girls is interesting for this problem.

Furthermore, how the problem is presented during the game activity and how the authors behave as role models will be determined carefully, as the gender expert emphasized that this could influence the participant's experience of the serious game.

6.2 Co-design Workshop

The co-design workshop resulted in 16 minigame ideas, excluding duplicates, which will be the basis for designing the minigame content for the serious game. Additionally, the participants mentioned a few points that will impact the structure of the game. The participants emphasized the importance of a good introduction to the field and repetition to facilitate learning. Thus, including an Introduction-module and Wrap-up-module is decided (**HR08** and **HR09**).

One participant emphasized the importance of explanations of the correct answer in the minigames connected to Boost Knowledge (**HR10**). It is vital to ensure that the participant can reflect on the tasks during the activity and possibly increase the learning potential. To explain tasks could be relevant regarding the tasks connected to the other learning goals, but it might not be necessary to explain all tasks, as that can be too repetitive. Additionally, before the tasks in the Boost Knowledge-module, it might be necessary to provide information about the addressed topic before the task in order to make sure that the level of the task applies to anyone, as the game should not require any prerequisites (**HR11**). As mentioned in Akre-Aas et al. (2021), trying to boost knowledge without providing the necessary resources can, worst case, cause low self-confidence, which is the opposite of the purpose of this game. Additionally, the workshop participants and the gender expert mentioned not to create minigame tasks, introductions to topics, or explanations with too much text, as that can risk losing the participant's attention (**HR12**).

A pattern in the results from the co-design workshop is that the Dialogue template is used several times. Thus, this minigame template will be used throughout the whole game, and the avatar in the minigame template will act as a Non-player character (NPC) that will guide the player through the tasks. The NPC will provide the player with motivational conversations as well as act as a role model for the participants (**HR13**).

Out of the 16 minigame ideas from the co-design workshop, most of them are used as inspiration for the serious game design. However, one minigame idea is not used, as the authors thought the content could work against its purpose and reinforce stereotypes, which the gender expert strongly warned. Additionally, the minigame ideas that were more aligned to another learning goal were changed. Then, each minigame was concretized according to the post-its connected to each idea to create complete tasks that could be implemented in Attensi.

6.3 High-level Requirements

As a result of the interview with the gender expert and the co-design workshop, high-level requirements for the serious game are created. These are presented in Table 6.1 and are the basis for the development of the game's first prototype.

Some impacts on the design are not influenced by the gender expert or the co-design workshop with female technology students. As written in Chapter 2, it is decided that the game will consist of several minigames, where each minigame will work towards one or more of the learning goals (**HR14**). In addition, the participants' discussions during the co-design workshop inspired the presence of an Introduction- and Wrap-up-module. Therefore, it is decided that the game will consist of six different parts, called modules (**HR15**). These modules will be the following: Introduction, Fight Stereotypes, Promote Self-confidence, Provide Role Models, Boost Knowledge, and Wrap-up. The order of the modules is influenced by the gender expert's thoughts regarding the learning goals. Additionally, if the game includes programming tasks, the game should use a programming language suitable for beginners (**HR16**). The game should be playable in a web browser (**HR17**).

Req.	Description	Source
HR01	The game should give the player a clear overview of the learning goals	Gender Expert Interview
HR02	Gendered labels and metaphors should be avoided in task descriptions	Gender Expert Interview
HR03	Awareness and interest in ICT as the learning objective	Gender Expert Interview Game Design Guidelines
HR04	The game should have creative tasks	Gender Expert Interview Game design guidelines
HR05	The game should offer short and concise feedback to the player	Gender Expert Interview
HR06	The minigames should avoid sexualization of female characters	Gender Expert Interview Game Design Guidelines
HR07	The game should offer some monitoring of the players that can be shown after play	Gender Expert Interview
HR08	The game should have an introduction that introduces the player to ICT	Co-design WS
HR09	The game should include repetition in the end of the game	Co-design WS
HR10	The minigames related to boost knowledge should be explained after the player has answered	Co-design WS
HR11	The game should offer necessary information needed before tasks so the player can answer without prerequisites	Co-design WS
HR12	The game should have concise task descriptions or in explanations	Co-design WS Gender Expert Interview
HR13	The game should have a non-player-character that motivates the player throughout the game	Co-design WS Game Design Guidelines
HR14	The game should be separated into several minigames, where each minigame work towards one of the game goals	Related Work
HR15	The game should be separated into different modules, each corresponding to one game goal	Game goals
HR16	The game should use a programming language suitable for beginners	
HR17	The game should be playable in the web browser	

Table 6.1: High-level Requirements

The high-level requirements are also based on the research done earlier in this report. For instance, the game design guidelines and the learning goals have also impacted the high-level requirements. Thus, Table 6.1 contains a column where the source of each high-level requirement is described. If there is no listed source, the authors have decided to include this high-level requirement on other terms. For instance, the high-level requirements **HR16** and **HR17** are based on the target group for the serious game. The requirements with a gray background are challenging to implement and will be discussed in Section 6.4.

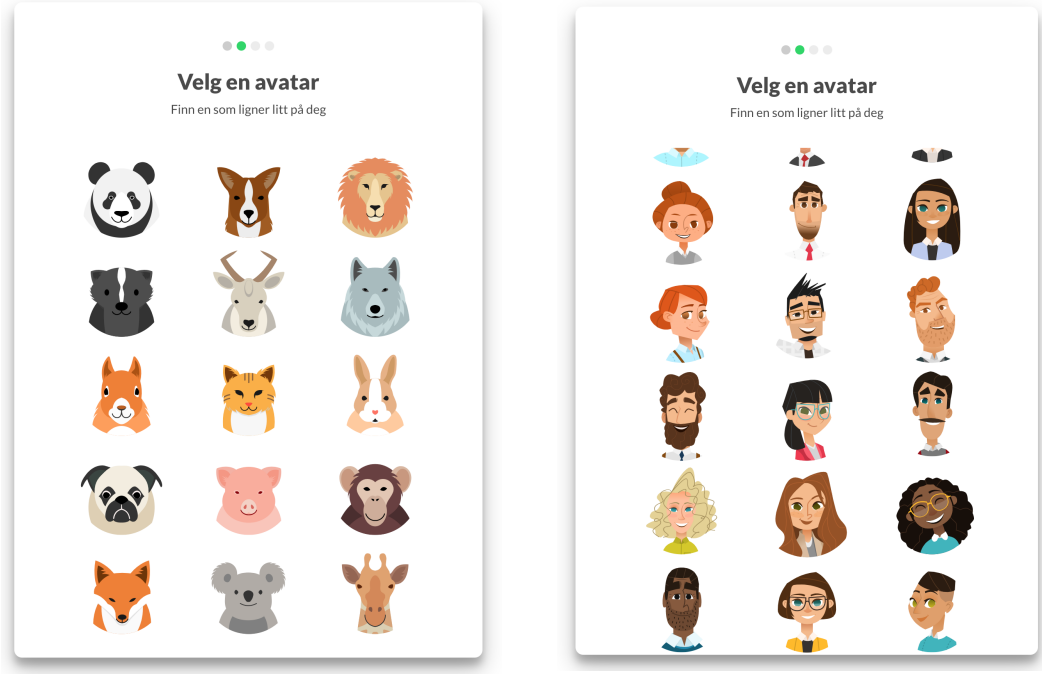
6.4 Discussion

Some of the results and suggestions from the co-design workshop and the interview with the gender expert are not achievable with the chosen game development platform. In this section, the different suggestions that can be challenging or cannot be implemented are presented and discussed.

Suggestions from Gender Interview

After presenting the game design guidelines to the gender expert, she emphasized that the choice of the avatar was crucial so that the player can express individuality. In Attensi, one can only choose between a set of already made avatars, as Figure 6.1 shows. The avatars are cartoons and can be both humans and animals. A wide range of human avatars are offered in gender, skin tone, age, and looks. In addition to choosing the avatar, one can choose a nickname. Therefore, players can choose an avatar and a nickname they identify with, but customization is impossible. However, the avatar plays a small role in the game since it is not present in the actual gameplay. The only place the player can see their avatar is on the front page, as shown in Figure 6.2. Therefore, one can argue that this limitation has a minor impact on the player's game experience.

One of the guidelines suggests incorporating creative tasks in the game, and the gender expert supported this. However, none of the minigame templates the



(a) Animals as avatars

(b) Humans as avatars

Figure 6.1: Some of the avatars Attensi offers

platform offers is suitable for incorporating creative tasks. The different minigame templates require a right or wrong answer, challenging to combine with creative tasks. Thus, **HR04** will be challenging to implement in the game.

Another guideline states that feedback on tasks should be constructive, and the gender expert supported this and stated that it should be brief and straightforward, as young players will be bored and not read long feedback. The platform does not support specific feedback depending on what the player answers. The only feedback is what the right and wrong answers for each task are and giving the player points according to their answer on each minigame. Therefore, one could argue that the feedback is brief and simple but not that constructive. The only minigame template that supports feedback is the Dialogue-template, where one can implement conditional answers. Thus, the Dialogue-template could include constructive feedback, depending on what the player chooses to answer in it. The limited options for conditional answers will impact the implementation of **HR05**.

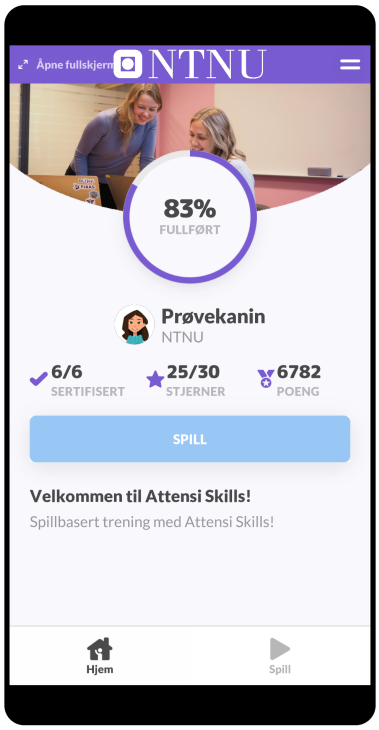


Figure 6.2: The avatar's role in the home screen

Suggestions from Co-design Workshop

Some of the girls in the co-design workshop suggested that there should be dependencies between some games. For instance, if the player answers wrong in one minigame, the player should play another minigame to learn more about it. While if one answers correctly, one will proceed to the next minigame. This suggestion could secure the learning outcome and explain to the player why their answer was wrong. However, this option is not available in Attensi. Only one of the minigame templates, the Dialogue, offers conditional replies depending on the player's answer. Therefore, if a minigame idea could benefit from getting conditional feedback and fit a dialogue template, it will be transformed and adjusted to this template.

One participant suggested having an info button on each image in the Multiple Choice games with images that could describe what the image was showing. This button is not a game mechanic the platform offers. Even though this option is

not available, a caption that describes the image could be added to clarify what the image is describing. Such captions will most likely be implemented in the first prototype.

A button the player could push to receive hints was suggested. There is no button function like this in the platform nor the opportunity to add one. Therefore, if hints should be incorporated, they have to be written in text. Additionally, another girl suggested that a hint should appear if the player has not answered within a given number of seconds. The function for doing this is not available on the platform. Hence the suggestion will not be included. However, it is worth mentioning that each module only contains a few minigames, and the modules can be played as many times as the player wants to improve their score.

Some texts in the Info templates and the Blanks templates in the results from the workshop were too long. The platform has some limits on the number of characters a text field can contain to ensure the game's usability. The maximum number of characters differs in each minigame template. Therefore, some of the texts are rewritten or shorten to fit the different templates. However, the essence of the tasks will be the same.

Lastly, some of the minigame ideas suggested, all of the options should be right or wrong. For instance, one minigame idea was a Multiple Choice template with images of different girls, where the question was "Which of these could work in the IT-industry?". All of the options should be correct options. However, Attensi requires that all questions should have at least one right and one wrong answer. Therefore, these minigame ideas were modified to fit these requirements if it was possible.

Even though Attensi comes with some limitations, it still offers good possibilities of creating an engaging serious game. If the game was to be implemented without using any existing tools or platforms, all guidelines could have been included. This would have been challenging due to the limited time and scope of this master's thesis. As stated in Akre-Aas et al. (2021), the game design guidelines may not be compatible to all co-exist in the same game. With the Attensi platform, it is possible to create a serious game that implements some of the guidelines in the minigames.

For instance, the platform has the opportunity to implement a realistic game world, offer status of progression to the player, awareness of ICT as the learning goal, NPCs, positive rewards and achievements, and more. Additionally, the platform facilitates learning trough including videos, text, audio, and images. Attensi is also compatible with many of the design suggestions presented in Chapter 3. It offers similar minigames in the framework created in Bellotti et al. (2012), for instance, the minigames Quizzes, VisualQuiz, Couples, Image Comprehension, RightPlace, CatchIT, Wrong or missing details, and Manuscript are available to implement. All instructions for the game can be incorporated, as recommended in Jonker et al. (2009), and the platform is based on creating series of minigames, as suggested in Frazer et al. (2007) and Arnab et al. (2021).

6.5 First Prototype

The first game prototype is going to be evaluated by a game expert. Due to Covid-19, the expert evaluation has to be done online, and a paper prototype is therefore not a suitable solution. Creating a digital prototype using wireframes in Miro was considered. However, the authors experienced how time-consuming creating detailed wireframes in Miro was through the preparation for the Workshop (Chapter 5). Additionally, the authors want to get accurate and comprehensive feedback on the first prototype. Thus, they decided to implement the first game prototype in Attensi. The game's first prototype will then be closer to the final game than with an online "paper" prototype. As Attensi is a no-code platform, it is a time-efficient and seamless option for implementing the first prototype.

The first prototype consists of four main modules, each corresponding to one of the learning goals: Fight Stereotypes, Provide Role Models, Promote Self-confidence, and Boost Knowledge. At the beginning of each module, the player is provided an information page, where a short text description and a suitable image are displayed before the module starts. In the first prototype, all modules are available for play at any time, as there are no conditional rules for which order the modules must be played yet.

When playing one module, the player instantly gets feedback if the answer or game was played wrong. The feedback is provided in terms of points popping out. There is a progress bar and an overview of the player's points on the screen. When the player has played one module, the player's performance is measured in terms of stars. On each module, the player can obtain 1-5 stars. All modules can be played as many times as the player wants. The game contains an NPC that the player can talk to through the dialogue minigame. This NPC is the player's motivator and role model throughout the game. The main objective of the game is to increase girls' awareness and interest in ICT. Thus, the first prototype aims to create relevant content for each learning goal, which altogether supports the learning objective.

Pictures and illustrations are included in the first prototype. However, instead of using time to record sounds, voices and finding appropriate videos for the game, this is put on hold until the next prototype of the game. The reason for this is that these elements might be eliminated from the game after the expert evaluation. Additionally, those elements were not crucial for the first prototype as there was limited time to develop it. Instead, only text without audio was used in the Dialogues. Additionally, in the video templates, the authors wrote what the video was supposed to be about so that the tester could imagine how it would be with the actual video there.

Other than inspiring the authors to create an Introduction- and a Wrap-up-module, the co-design workshop and the gender expert interview have no implications for designing the content of these modules. As there were no design suggestions for these modules, they were not implemented in the first prototype. Additionally, leaving out the Introduction-module and the Wrap-up-module in the first prototype is intentional, as the authors want to get feedback and suggestions on what these modules can contain in the expert evaluation of the first prototype. Lastly, creating an Introduction- and a Wrap-up-module without knowing what content to introduce or summarize is challenging. Thus, the four main modules regarding the learning goals have to be created first. The four main modules are designed in the following way in the first prototype:

The **Fight Stereotypes**-module consists of four minigames. This module introduces the player to the NPC and tries to give a better understanding of what a

developer is. The player gets tested by needing to answer what characteristics a developer has and what kind of people work in the ICT-field. Also, info about the importance of diversity in ICT is included.

The **Provide Role Models**-module consists of six minigames. The minigames highlight Ada Lovelace, the world's first programmer. In addition, some other female role models who have impacted the ICT-field are introduced. Lastly, a designer and a tester present themselves through a Dialogue minigame.

The **Promote Self-confidence**-module consists of six minigames. This module emphasizes that the player could study ICT if they want to by asking the player about their abilities and personal skills through dialogues. In addition, the module aims to make the ICT studies less scary and difficult by, among other things, stating that one does not need to know to program beforehand to create self-confidence in the player.

The **Boost Knowledge**-module consists of ten minigames. This module tries to get the player interested in ICT by explaining what it is and how it affects the world. It also presents some basic ICT concepts, like HTML, databases, and if/else statements. In addition, some of the minigames underline why women will benefit from having more girls in the technology field.

7 First Prototype: Expert Evaluation

This chapter presents the expert evaluation of the prototype described in Chapter 6. The evaluation is done through a semi-structured interview with a game expert. The purpose, participant, and the process for the interview are described in Section 7.1, while the results are presented in Section 7.2. The expert evaluation is discussed in Section 7.3. Here, additions to the list of high-level requirements and limitations from the expert evaluation are presented. The game expert has approved the content written about her statements in this chapter.

7.1 Game Expert Interview

An interview with a game expert is conducted to get feedback and insight regarding the prototype. The purpose of the interview is to get insight into what should be improved, removed, or implemented in the next iteration of the game. The interview questions are based on the prototype and the different minigames in the game. Also, some questions revolve around the learning objective of the game. These questions aim to give insight into what extent the different minigames fulfill the learning goals to ensure that they support the learning objective.

The interview was semi-structured, and the interview guide can be found in Appendix B.2, allowing a combination of predefined questions from the interview guide and the possibility to converse freely about the impression of the modules. Thus, it is worth noting that not all questions were asked as topics already got

covered through follow-up questions throughout the interview. Before the interview was held, the interviewee signed a consent form containing information about the project, how the data will be used and stored, and the rights connected to the data used in this thesis. This consent form can be found in Appendix D.3.

The interviewee is an expert on educational games, specifically specialized in game-based learning and designing and evaluating such games. Currently, the game expert is finishing a Ph.D. in games for learning. The game expert has developed a framework to help analyze, design, and evaluate games for learning. She was recruited through the researchers' network.

The interview was conducted over Zoom and recorded using the software's built-in recording function. As the interview revolved around the first prototype, the game's purpose and target group were introduced to the interviewee. Then a demo of the game was held by the game developers by screen sharing the game on Zoom. Specific questions were asked consecutively after each module had been demonstrated to discuss that module in the demo. The same questions were asked about each module. The interviewee was also encouraged to provide other feedback about the game. After the demonstration of the whole game, the interviewee was asked some general questions about the game. Both authors transcribed the recording from the interview to secure a correct transcription. Then the results from the interview were coded using the same procedure as in the interview with the gender expert in Chapter 4.

7.2 Results

The interview results are divided into two parts: one relates to the modules, while the other relates to the game in general.

7.2.1 Evaluation of the Modules

Fight Stereotypes

When the interviewee was asked about the first module, Fight Stereotypes, it was stated that the order of minigames was acceptable. However, the interviewee mentioned that one minigame, in particular, only plain text without any interaction from the player, could be improved. It was suggested to improve it by either adding some audio to the text or animation to explain the topic introduced in that minigame. When it comes to the learning objective in this module, the interviewee stated that the module was too plain and not gamified enough to the extent that the learning goal was incorporated within the game objectives. The interviewee mentioned a lack of actions in the game that triggered the gendered stereotypes in Information and Communication Technology (ICT). Thus, the inclusion of a scenario where the player has to choose between options fighting against stereotypes was suggested.

Additionally, to reduce the text amount in the game, an introduction video was proposed at the beginning of each module. Specifically, the interviewee stated: *"When you have too much text within the game, as you are making it for teenagers, they would just skip it or they would just not want to read the text"*. Thus, a suggestion was to have audio or animation, or visual instructions instead of text.

Promote Self-confidence

Once again, the interviewee suggested using video instead of text in the long explanations. In particular, it was suggested: *"If you use a video where you are showing a scenario about how technology is solving some of the problems, then the player can choose one problem and see one way that ICT is dealing with it through an animation or a video"*. When it comes to the game part of this module, the game expert stated that the game part was weak and suggested incorporating more engaging games. Additionally, some suggestions were to have more gamified elements, like timers, badges, or rewards.

Provide Role Models

In this module, the interviewee mentioned that the order was accepted. However, the module ended with a Dialogue-minigame, and the interviewee stated that it was weird that the module ended without a game to test if the player understood that part. Thus, a suggestion was to link an activity to every explanation of a technical role. Additionally, the interviewee suggested explaining the roles through videos or animations instead of text, which might motivate the target group. When the interviewee was asked about the number of minigames in this module, she stated: *"I think you should have a bit more minigames. I think this module is more content than the game part."* The interviewee did, however, like the dialogue. In addition, small minigames after each role were suggested to increase the learning part within this module and the game.

Boost Knowledge

The game expert thought the minigames supported the learning objective in this module but suggested improving the module to be more game-like. In terms of the order, the last minigame, a Dialogue-minigame, was suggested to be moved earlier in the module or a separate module containing real-life examples of the application of ICT, possibly through videos. In the coding minigame, the game expert proposed incorporating a more visual programming language, where the player can see the impact of each code statement. Scratch was mentioned as a good language that could be an efficient tool for teaching programming to the target group.

7.2.2 General Evaluation of the Game

Introduction and Wrap-Up

When the interviewee was asked about suggestions for what to include in the Introduction-module, the answer was to include scenario-based minigames using a

character. One suggestion was to use scenarios to introduce the player to the field, or a role-based game, where the player can act as a designer, developer, or another role within ICT.

Regarding the last module in the game, the Wrap-Up-module, the game expert suggested including a part about ICT in different industries. This part is included in the Boost Knowledge-module, so the game expert suggested moving that part to the Wrap-Up. Additionally, the interviewee suggested extending that part to use ICT in some of the different areas or learn more about it in the actual industry. Another suggestion was to let the player choose a role and then get a chance to test it out through a scenario, using skills they have already learned throughout the other modules. In short, the game expert advised creating the Wrap-Up to summarize and repeat the content from the prior modules.

General Feedback

In general, as the game aims to increase girls' awareness and interest in ICT, the game expert suggested including characters from the field in the game. In that way, the players can feel associated with their character. Additionally, the game expert suggested using scenarios where the player is shown the gender gap and how the character can overcome the challenges.

When the interviewee was asked about the game's length, she stated that each player needs to finish the game to secure that the learning goals are reached. Additionally, as the target group is teenagers, the game expert stated that the game should not take more than 50 minutes to complete, as the engagement and time to focus is shorter for teenagers than adults. In terms of the number of minigames, the game expert emphasized the importance of various games. *"I think it is good to have many minigames because when you have variety, it engages them more, because if you have seen the same thing repetitively after a while, they start getting bored"*. To sum up, the game expert stated: *"If you have different minigames and different modules, I think it will get more attention and it will increase their attention span as well"*.

Regarding the use of minigames to address this problem, the game expert was positive. The game expert had previous experience with minigames. Based on that experience, the children preferred playing a game with minigames over playing the same activity but with different content every time, as they got bored. Thus, the game expert stated: *"I think the using minigames and using different minigames is a good idea"*. However, the game expert stated that as the players are only going to play the game one time, it would be good to link all the modules together, as that might be more engaging and feel like they are progressing in the game.

When the interviewee was asked which media form is the most effective, the answer was to use a combination of video, audio, and text, as they have a different impact. For instance, in the parts where the player is given instructions, a visual-based or video-based approach is suggested by the game expert. However, it is stated that in short instructions, a text might be the best, as the player can reread it. All in all, the game expert advised using a combination of media forms. Additionally, the game expert was asked which game elements could be motivating and increase engagement in minigames. Game elements like time limits, characters, rewards, and points were mentioned, and the points could also be used to buy things for the character so that the player can enhance their character.

When asked whether she thought this game could increase teenagers' understanding of ICT and help close the gender gap, the gender expert thought it would be beneficial. However, it was stated that it could be even more improved but using characters or making it more game-like. She thought that the game, in general, gives an excellent introduction to the field by introducing the skills, roles, and real-life examples, which altogether is an excellent introductory material. The game expert did also mention that this game could be equally motivating for boys as well.

7.3 Discussion

After the expert evaluation of the prototype, some new high-level requirements are created. These will come in addition to the ones already described in Chapter 6.

The new high-level requirements are assigned a priority and a difficulty to make the development process easier when the time constraint starts to tighten throughout the project. The new high-level requirements are shown in Table 7.1.

As the game expert mentioned, the game should not take more than 50 minutes to play; a new high-level requirement is created (**HR18**). This high-level requirement is assigned a *High* priority, as most players must manage to finish the game during the game activity. Additionally, it is essential for the learning objective that the player touches on all four learning goals. **HR18** is described with *Medium* difficulty, as it is not easy to predict a general playing time. Different players will have different paces and progress in the game. Thus, the number of modules and minigames must be adjusted to manage to finish the game within the time limit, not only the fastest ones. In order to secure that this high-level requirement is achieved, the time consumption of the game will be tested in the pilot test of the second prototype.

The game expert emphasized the importance of variety among media forms. Thus, a high-level requirement that the game should include different types of media forms (**HR19**) is added. It is, however, important to mention that Attensi has some limitations when it comes to a wide range of media forms, so this high-level requirement is considered as *Medium* difficulty. One can add videos to Attensi, but they need to be uploaded to the platform. Thus, one can not embed public videos in the minigames. Therefore, this requirement will become very time-consuming if the researchers have to create videos instead of being reused from open-source videos found online. However, the requirement is assigned as *High* priority, as the game expert mentioned the importance of variety and the consequences of not achieving this.

The last high-level requirement that is added after the expert evaluation of the game is considered as *Medium* difficulty. The high-level requirement is the following: *The modules in the game should be linked together, so the player feels progression in the game.* (**HR20**). Because of the authors' previous experience with the platform, they know that this can be done, but not how. Therefore, this has to be investigated further to find out how. Nevertheless, the requirement is *High* priority, so finding some solution that can link the modules together will be prioritized.

Req.	Description	Source
HR18	The game should not take more than 50 minutes to complete	Game Expert
HR19	The game should include different types of media to communicate to the player	Game Expert
HR20	The modules should be linked together so the player feels a progression in the game	Game Expert

Table 7.1: High-level Requirements from the Expert Evaluation

A possible limitation of the evaluation is that the interviewee is not fluent in the language used in the game. Therefore, the tasks were translated and explained during the game demonstration to ensure that the interviewee had a sufficient understanding to answer the questions. The game was carefully described, so it was no big misunderstandings during the interview. The authors believe that the thorough demonstration was an important tool to ensure that the interviewee could give an expert evaluation of the game either way. Additionally, this evaluation's purpose was not to refine the language and formulation used in each task; it was more about the overall impression. A more thorough review and refinement of the language and formulations will be done during the creation of the second prototype, described in Chapter 8.

Some of the suggestions the game expert proposed can not be realized with the chosen platform. One suggestion was that the player could customize the clothing and other aspects of the avatar to feel a stronger association with the character, which can not be done as discussed in Section 6.4. There are challenges connected to what can be done with the time, badges, and rewards, which were game elements the interviewee suggested to include. In some of the minigames, the time limit can be adjusted to change the difficulty level. Further, Attensi has a built-in scoring function, which gives the player points depending on the correctness and how fast the player answers. The number of points can be tweaked on each task, but one can not receive other rewards than points. There are also given extra time-bonus and answer-streak points. After the player has played one module, one can achieve certifications, depending on the achieved points in the module. It is possible to adjust how many points are needed to achieve a specific certification. Other than the points and certifications, no other form for reward is possible to include. Also,

the interviewee suggested that one could use points to buy things to enhance the avatar, which can not be done as points are only used to indicate how well a player has performed on a module.

The interviewee also mentioned that a coding minigame should incorporate a visual programming language, where Scratch was mentioned as a possible candidate. To integrate Scratch in one of the minigame templates is not possible within the platform. In addition, none of the templates supports the execution of code snippets. Therefore, the only types of programming tasks possible to make are text-based. Text-based tasks can be implemented by, for instance, using the Ranking-template to make a game where one could sort lines of code in the correct order, or by using the Text Input-template to make a game where one would have to write the missing line of code.

8 Final Game: XploreIT

8.1 Second Prototype

After the expert evaluation was conducted, the feedback and suggestions from the game expert were used to create the second prototype. The main feedback points presented in Chapter 7, are summarized in the list below and used to develop the game further:

- Multi-modal game: Use a combination of video, audio, images, and text
- Reduce the amount of plain text
- Include introduction videos to the modules
- Include more gamified content and engaging games
- Each informative minigame should be followed up by an interactive minigame
- Include some scenario-based minigames
- Use the Wrap-up module to summarize and repeat content

All the high-level requirements that were added after the expert evaluation in Chapter 7 are implemented in the second prototype. **HR19** will be evaluated in the pilot test (Section 9.3). **HR20** is fulfilled by the incorporation of videos and audio in the game. Some descriptions that originally were text are changed to audio or video so that the game is multi-modal. The last requirement, **HR21** is fulfilled by changing the game mode from Grid, where the player can play whatever

module he/she wants, to a Map, where the order of the modules is predefined. The modules are now in this order: (M1) Introduction, (M2) Fight Stereotypes, (M3) Promote Self-confidence, (M4) Provide Role Models, (M5) Boost Knowledge, and (M6) Wrap-up. The order is the same as intended in the first prototype.

The second prototype has more minigames, as the game expert wanted the game to have more engaging games. A new minigame, the Runner-minigame, was released on the platform after the workshop (Chapter 5) was held. In this minigame, the player has to control a rolling ball by avoiding obstacles and wrong answers and catching the correct answers. This minigame has been included in several modules, as it is engaging and game-like. A Hotspot-minigame that was not included in the workshop in Chapter 5 has been included in the game to create a wider variety of minigames. In the Hotspot-minigame, the player shall click on some spots on an image where certain items are. An example question for this minigame is: "Click on each country on a map where their native language is English."

In addition to the changes from the expert evaluation, the second prototype is more complete than the first prototype. The second prototype is considered complete enough that it could have been the final version. The Introduction- and Wrap-up-modules are created and complete. The minigames are complete with both images, audio, and links to the public videos. Visually, the color scheme for the game is set, backgrounds in Dialogues are chosen, and the map-overview of the modules is created with the correct colors and with appropriate icons that illustrate the modules. Additionally, the minigames are checked for typos, and the explanations, descriptions, and answers have been shortened to be more concise.

8.2 Game Description

The serious game is named XploreIT, as the game lets the player explore Information and Communication Technology (ICT) through the many minigames and modules. The game is played in the web browser and can be played on any browser that supports WebGL[1], which is a JavaScript API for rendering interactive 2D and

[1] `https://get.webgl.org`

3D graphics. The game is divided into six different modules, which are described further in Section 8.2.2. XploreIT utilizes multiple game elements, which are described in Section 8.2.1. Further, a subset of the game design guidelines are included in the game, and these are described in Section 8.2.3

8.2.1 Game Elements

XploreIT has several game elements integrated into the minigames the game development platform provides to make them more engaging. These game elements are presented in this section, in addition to some game elements the authors have incorporated. At the beginning of the game, the player can choose an avatar among 90 predefined avatars. The avatars are animals and humans, which vary in gender, ethnicity, age, and appearance. The game has a realistic game world with realistic avatars to show the diversity in the field and good graphics which shall combat stereotypes.

The player is introduced to a Non-player character (NPC) shown in Figure 8.1, which should act as a role model and motivator. The NPC is present several times in the game, providing different information and instructions to the player. When the player plays a minigame, instant feedback is provided if the answer was correct or not. For instance, if the player answers correctly in two different minigames in a row, the feedback in the game can be "Combo," which pops up on the screen. If the player is particularly fast in playing one minigame, feedback showing "Quick Answer" will pop up on the screen.

Status as a visualization of learning progression is shown at the overall game map (Figure 8.2), where the player can see how far she has come on the "path." Additionally, when playing one module, the progress is shown as a progress bar on the top of the screen. When the player plays one minigame, points are given as a reward for the correct answer. These points are added to an overall score. When the player finishes a module, the overall score is converted into stars, which can be seen as an achievement. The player can get 1-5 stars in each module. If the player gets over three stars in a module, the player achieves a "certification."

Figure 8.1: The NPC in XploreIT

Figure 8.2: The map in XploreIT

8.2.2 Game Modules

This section describes the modules in detail. The modules must be played consecutively: When the first module is played through, the next is unlocked. The overview of the different modules can be seen in the game map, as seen in Figure 8.2. All the modules consist of different minigames, where the player can play each module as many times as wanted to improve the score.

Module 1: Introduction

The purpose of the Introduction-module is to set the context of the game and give an introduction to ICT. In addition, the player will be introduced to the NPC which will guide the player throughout the game. This module consists of four

different minigames shown in Figure 8.3. Before the module starts, the player will watch a video called "Computer Science is Changing Everything," which shows the impact computer science has on many different fields. The first minigame is a Dialogue, and the NPC, Selma, introduces what the module consists of and what is needed to play the game. After this, a Multiple Choice Text question appears, asking the players what they think programming is. Then, a new Dialogue with the NPC appears, which is meant to illustrate the importance of ICT, as a follow-up to the video they watched. Lastly, the Info-minigame is used to summarize what they have been introduced to in the module.

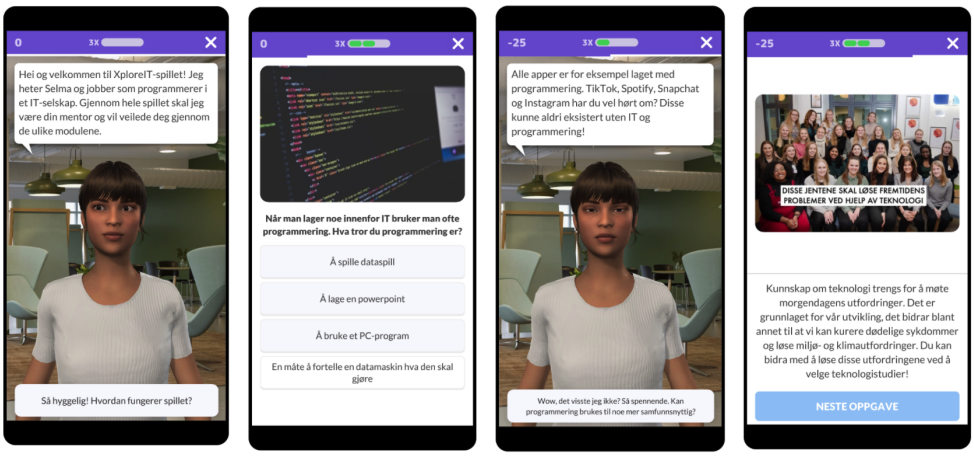


Figure 8.3: The minigames in Module 1: Introduction

Module 2: Fight Stereotypes

The purpose of the Fight Stereotypes-module is to fight stereotypes people have about the persons working in the ICT-field. This module consists of seven different minigames, shown in Figure 8.4. Before the module starts, the player will watch a video called "Gender Stereotypes and Education," which explains that gender stereotypes are ingrained in people from an early age and affect the different genders. The first minigame uses the Dialogue, where the player gets to talk with a software developer and is told about the profession. After this, a Bubble-minigame is used to test what they have learned by popping the bubbles characterizing a software developer. Then, images with different women appear in a Multiple Choice Image

game, where the player has to choose the one that does not work in the ICT field. In the fourth minigame, the player has to fight their stereotypes in Dialogue with a man and the software developer from earlier by defending who can be a software developer.

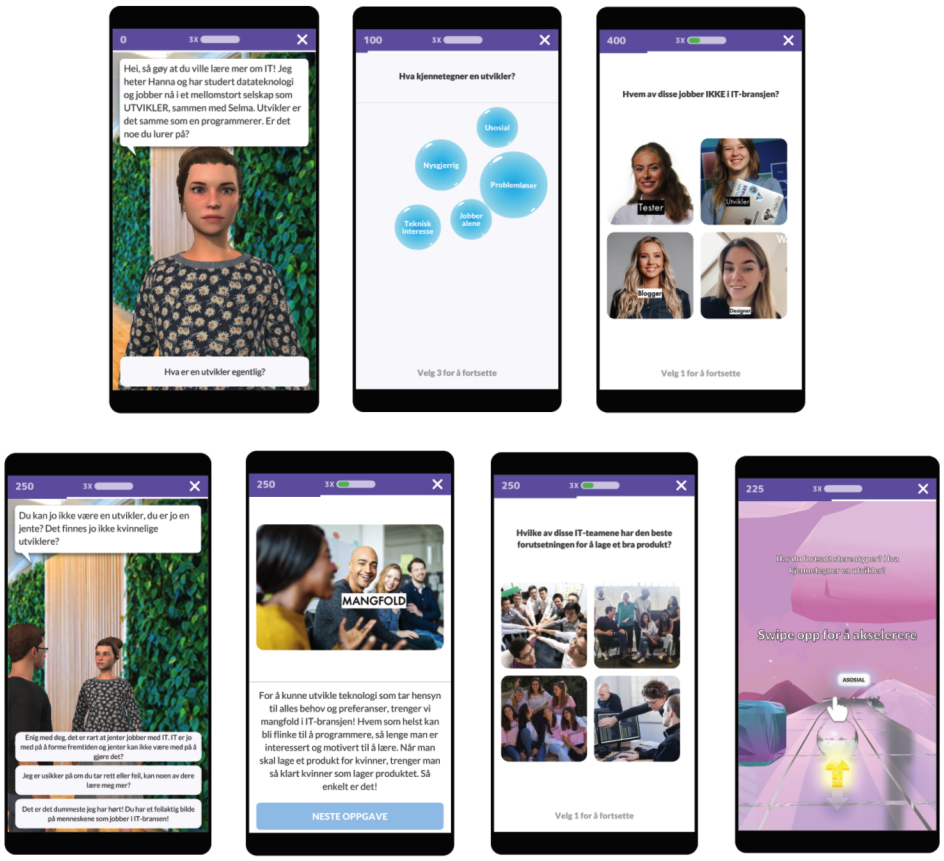


Figure 8.4: The minigames in Module 2: Fight Stereotypes

Further, the importance of diversity in a field is explained in an Info-minigame, tested in a Multiple Choice Image game. In this game, the player has to choose which ICT team has the best premise for making a good product, where the correct answer is the team with the most diversity. Lastly, the player should test if they still got stereotypes by playing the Runner-minigame, which contains repetition questions from the module.

Module 3: Promote Self-confidence

The purpose of the Promote Self-confidence-module is to give the player more confidence toward her ICT-abilities and show that everyone can work in the ICT industry, as self-confidence is essential for increasing learning and motivation. Before the module starts, the player will watch a video called "Vi trenger flere jenter til teknologistudier" (Translated: We need more girls to technology studies), where a female ICT student explains how the study program is and why more girls need to choose it.

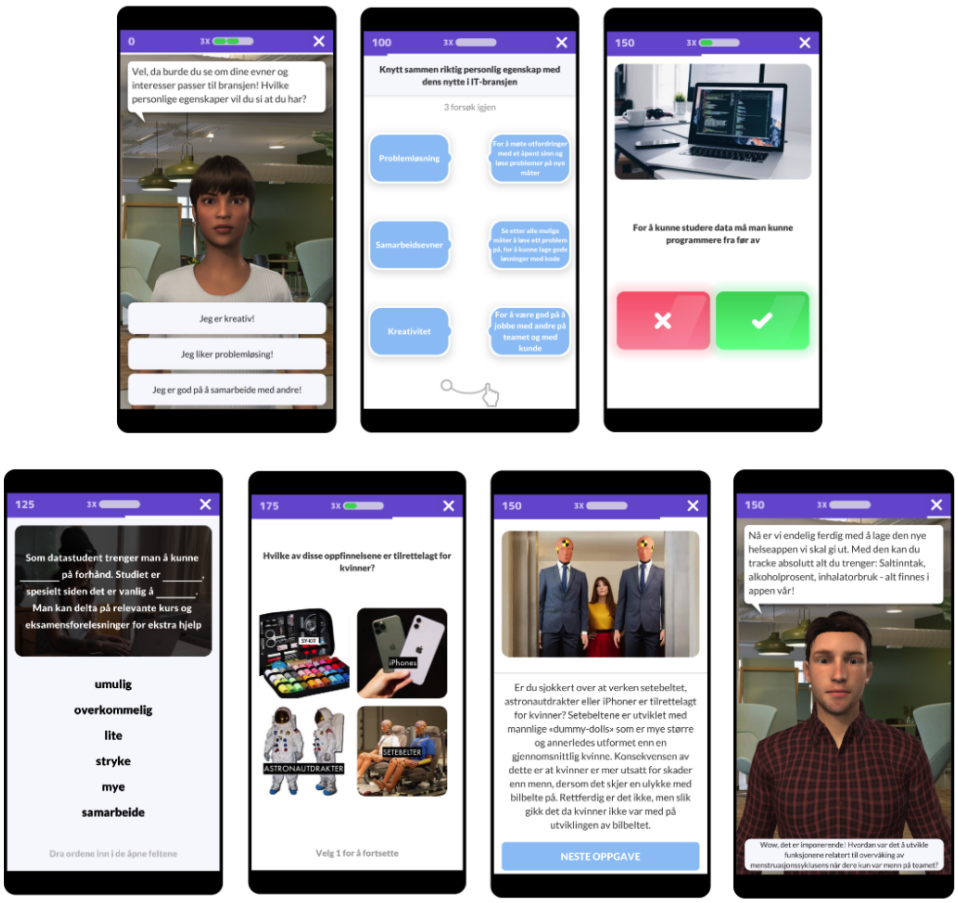


Figure 8.5: The minigames in Module 3: Promote Self-confidence

This module consists of seven minigames shown in Figure 8.5. The first minigame is a Dialogue with the NPC, where she asks the player which personal skills the

player beholds; depending on what the player answer, the NPC will explain how this personal skill is valuable in the ICT field. The second minigame utilizes the Connect-minigame, where the player shall connect the right personal skill with its value in the ICT field, which is knowledge from the previous. The third minigame is a True or False game, where the player should decide whether one has to know programming beforehand to study computer science. The correct answer is false.

Further, a Blanks-minigame about the ICT study is included, showing that the study program is not as complicated and lonely as some imagine. The fifth minigame is a Multiple Choice Image game of different inventions, where the player should pick the inventions that are not adapted for females. After this, an Info-minigame explains how not having women in technology affects the inventions, as the previous game exemplified. The last minigame utilizes a Dialogue-minigame and is scenario-based, where the player can influence the functions in a health app.

Module 4: Provide Role Models

The purpose of the Provide Role Models-module is to introduce the player to role models they can look up to and be inspired by. This module consists of eight different minigames shown in Figure 8.6. The first minigame is a True or False game with the statement "The first programmer in the world was a woman," where the correct answer is true. Then, an Info-minigame is used to tell about Ada Lovelace, the world's first programmer. To test if the player has learned something about Lovelace, a Blanks-minigame is used: the player must fill in the correct words in a text about her. Then, two more female role models in the ICT field are introduced in an Info-minigame. In the fifth minigame, which utilizes the Connect-minigame, the player must connect the suitable role model with the suitable contribution. The Dialogue-minigame is used in the two following minigames, where the player is introduced to a designer and a tester. Lastly, a Swipe-minigame tests whether the player remembers the difference between what a designer and a tester do.

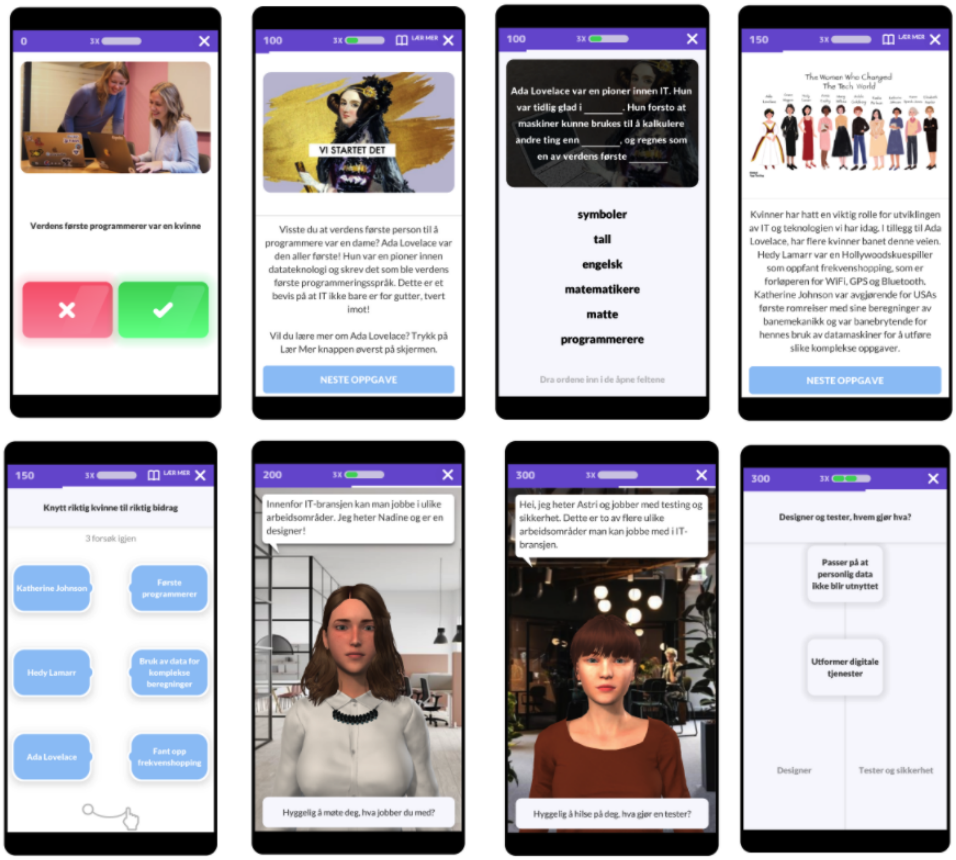


Figure 8.6: The minigames in Module 4: Provide Role Models

Module 5: Boost knowledge

The purpose of the Boost Knowledge-module is to give the player a deeper understanding of what ICT is and how it affects the society by presenting some basic concepts within the field. This module consists of nine different minigames shown in Figure 8.7. The first minigame consists of a Connect-minigame, where the player will repeat what she has learned by connecting the proper ICT role with the correct description of it. Then, an Info-minigame is used to explain some common technologies and mention programming languages briefly. Further, the info will be tested by combining the right technology with the correct description in a Connect-minigame.

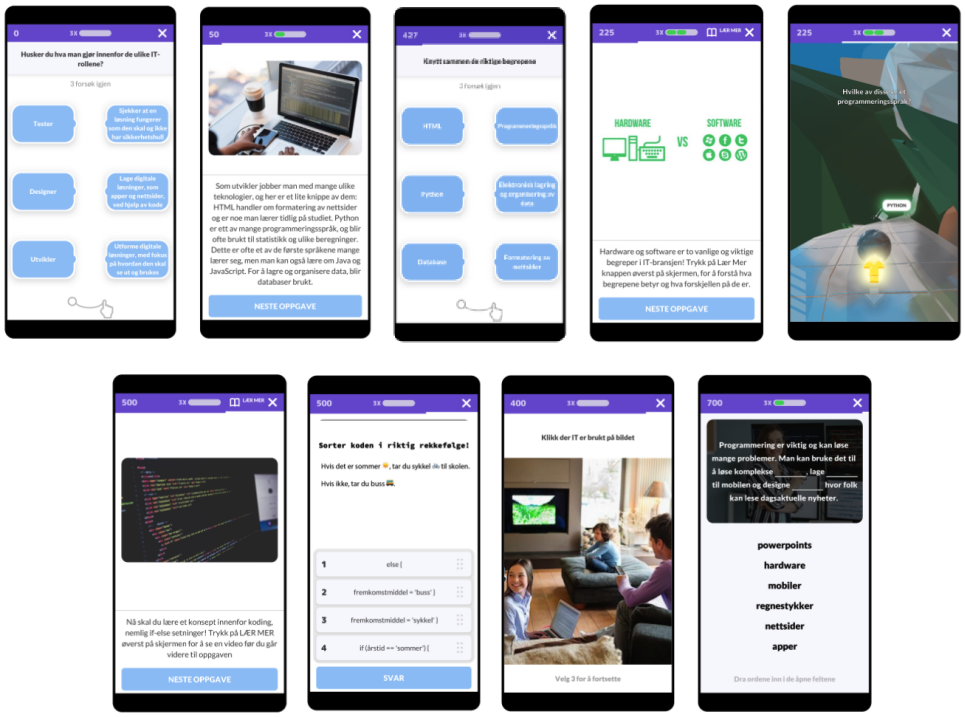


Figure 8.7: The minigames in Module 5: Boost Knowledge

Further, hardware and software are introduced in an Info-minigame, where the player also can watch a video explaining the concepts further. As the fifth minigame, the Runner-minigame is used to repeat the knowledge introduced so far in the module. After this, an Info-minigame about "if/else"-statements is included, where the concept is explained through a video. To let the player try to use computational thinking and test their new knowledge about if/else-statements, they have to sort the code snippets in the correct order in the Ranking-minigame. In the eighth minigame, the player has to click on places ICT is used in a photo, which is done by using the Hotspot-minigame. Lastly, Blanks-minigame is used, where the player has to fill in the right words about programming.

Module 6: Wrap-up

The purpose of the Wrap-up-module is to bring everything they have learned together. Before the module starts, the player has to watch a video called "Jenter og teknologi" (translated: Girls and Technology), which includes many aspects as the ones presented throughout the previous modules, such as the fact that technology is not made for females, the need for more girls and the importance of ICT for the society.

This module consists of three minigames shown in Figure 8.8. The first is a Dialogue with the NPC, where the player can choose to learn more about how technology is utilized in the health sector, community, or for sustainability. Secondly, the Runner-minigame is used to repeat three questions taken from the previous modules. Lastly, a Dialogue with the software developer character is included. In this dialogue, the player can find out how one should proceed to learn more about ICT, either in their spare time or in a school context.

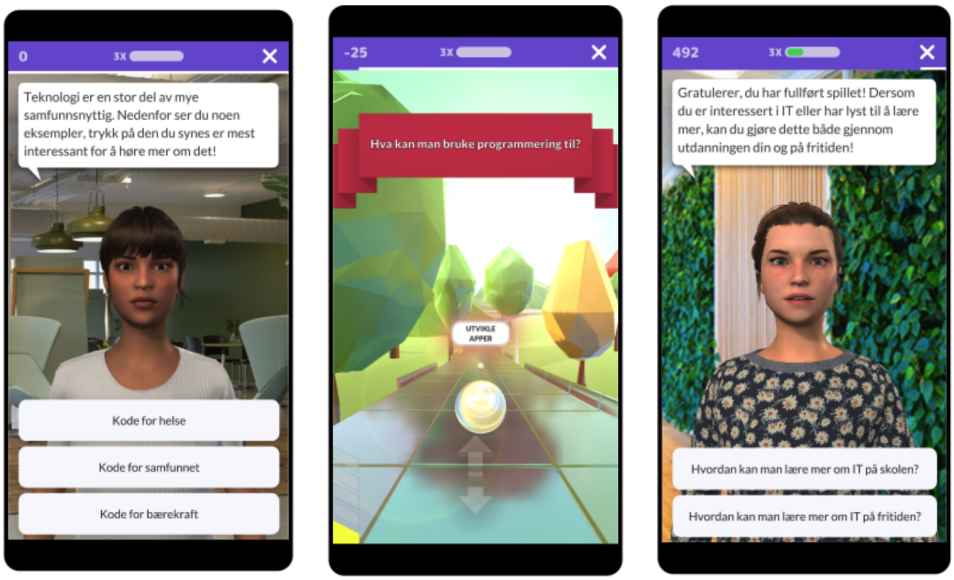


Figure 8.8: The minigames in Module 6: Wrap-up

8.2.3 Game Design Guidelines

In total, XploreIT fulfills 10 out of the 16 game design guidelines in Akre-Aas et al. (2021). As mentioned in Section 8.2.1, the game has rewards and achievements (G2), feedback on the player's performance (G3), and status as a visualization of progress (G4). The players can choose an avatar to identify with (G5a) but not customize it, and it is unsure whether these avatars remove stereotypical images of programmers (G5b). Thus, this guideline is only partly fulfilled. G6 and G7 are achieved through the looks of the game. The learning objective of the game is awareness of ICT (G8), and there are problem-solving tasks to facilitate learning programming (G9) in the fifth module, Boost Knowledge. The game has an NPC which acts as a role model and motivator (G13). There is no violent content in the game, and no characters are sexualized (G15, G16).

9 Final Evaluation

The final game, as described in Chapter 8 is evaluated with the target group to determine if the minigame-based serious game increases girls' awareness and interest in Information and Communication Technology (ICT). The purpose of the final evaluation is described in Section 9.1, and the process is described in Section 9.2.

Before the final evaluation of XploreIT, a pilot test, which is described in Section 9.3, is held. The final game is evaluated by the target group in a game activity session, which is described in Section 9.4. The results from the final evaluation are gathered from observations, questionnaires, and gameplay data and presented in Section 9.5. Further, the results are discussed in Section 9.6.

9.1 Purpose

The overall purpose of the final evaluation of XploreIT is to assess the potential of the serious game to address the problem. The evaluation will cover the potential of using minigames to increase the awareness and interest in ICT for the specific target group.

First, a pilot test will be conducted to test the evaluation plan. Then, the target group will evaluate XploreIT to give insight into what extent the learning goals are supporting the overall learning objective of increasing girls' awareness of and interest in ICT. The participants will answer specific questions regarding each module in pre- and post-questionnaires, giving the researchers insight into entertainment, learning, awareness, and interest. By comparing the data collected through pre-and post-questionnaires and the gameplay results, the authors can be able to see if

there is a connection between how a player performed and the game's impact on the player. Lastly, the final evaluation will give an indication of whether the game contributes to fighting stereotypes, provide role models, promote self-confidence and boost knowledge about ICT among the target group.

9.2 Process

The pilot test was performed in the same environment as the game activity and was conducted to test the game activity plan for the evaluation from the start until the end. The pre- and post-questionnaire are included in the pilot test to ensure that all questions are clear and feel relevant to answer according to the participant's experience with the game.

The evaluation with the target group was conducted in four different game activity sessions and was held in the same manner. The sessions were held through a video call with the participants by using Zoom or Teams. All participants from the same school evaluated the game in the same session. First, the project and the plan for the session were introduced. Then, usernames and passwords were distributed, and some instructions on how to log in to the game were given. A document containing the exact instructions was sent to the participants, available for use if needed during the game activity session.

After the introduction, the participants answered the pre-questionnaire, which can be found in Appendix C.1. Then, they played the game, and finally, they answered the post-questionnaire, which can be found in Appendix C.2. During the participants' gameplay, the researchers were observing and taking notes of behavior, comments and any problems that might have occurred. All four sessions were conducted during the participants' school hours, and all participants in the same session were together in the same classroom. During the sessions, the teachers were not present. Thus the researchers were supervising the participants while they played the game. The participants were encouraged to ask questions if there were any problems or confusion during the gameplay.

Summarized, the plan for the gameplay activity is the following:

1. Introduction
2. Participants answer pre-questionnaire
3. Gameplay
4. Participants answer post-questionnaire

9.3 Pilot Test

A pilot test was conducted to test if the tasks are understandable, check the amount of time it takes to play the game, and find vulnerabilities. The gameplay session from start to end is also tested, including answering the questionnaires before and after the gameplay to check that the questions are not ambiguous.

The participant was recruited through the researchers' network. The participant was a co-student of the authors but did not have previous experience with game development. First, the participant was introduced to the project and how the pilot test will be conducted. The participant was told to think aloud and tell us whenever she had feedback on the game, which the authors noted. The participant first answered the pre-questionnaire. Then, the participant played the game and gave continuous feedback while playing the six modules. Lastly, the participant answered the post-questionnaire after she had played the game.

9.3.1 Results

The results from the pilot test will be presented in this section and used to improve the game and the gameplay session. Firstly, the game consists of several links to public videos about relevant concepts. The participant mentioned that it would be good to get a brief message explaining that a new window will open when such a link is clicked. Regarding sounds, the participant liked the sounds and the game

elements. However, she mentioned that some sounds were too loud. Additionally, it was discovered that the map had a buggy behavior when she scrolled on the screen. The participant played the game for approximately 30 minutes. She had no feedback on the game content other than that the games were understandable with thorough descriptions and explanations.

No improvements were mentioned for the pre-questionnaire. For the post-questionnaire, the participant mentioned that the question *I think ICT is fun after having played this module* was too specific. She said that it was difficult to separate the modules and answer that question. The same applied to this question: *I have learned something about ICT from playing this module*. Other than this, the questionnaires were reported as understandable and comprehensible for the participant. Both questionnaires collected the data correctly, ensuring that the participant was anonymous. The participant finished the questionnaires in a reasonable time, and the responses covered the desired answers. The pilot test lasted less than one hour, and there were no technical challenges throughout the test.

9.3.2 Changes Made as a Result of the Pilot Test

The pilot test resulted in some suggestions for changes that should be implemented before the final evaluation. Firstly, a brief message saying *The video is opened in another window* is added in the game when the first public video link is shown. The buggy behavior that happened when the player scrolled on the map was also fixed. Regarding the loud sounds that the participant pointed out, nothing was changed, as adjusting the sounds was impossible.

There were not done any changes to the pre-questionnaire. The post-questionnaire was modified after the pilot test, and the two questions mentioned in Section 9.3.1 were removed, as the participant perceived these questions to be vague and difficult to answer.

It was noted that it could be hard to follow and remember all the instructions given orally. Thus, a document with an overview of the game activity plan and

clear instructions on how to log in and what to do if the browser blocks video links were created. The document will be explained and provided to the participants before they begin the activity and act as support besides asking the researchers for help.

9.3.3 Discussion

The pilot test did not test the game's impact but rather the whole process for the final evaluation. The pilot test did test the minigames, and the participant said they were understandable. However, the participant was older than the target group and had more knowledge of ICT than an average secondary school student. Thus, the pilot test might not have revealed issues regarding the level of the tasks.

As mentioned, the participant played the game for approximately 30 minutes. In the pilot test, the participant only tested if she could open and watch the first video. Other than this, none of the videos were opened and viewed, as the authors found this unnecessary. In total, the game contains video material that takes 12 minutes to watch. Even though the videos were not included in the pilot test, one can argue that an estimated time to play the game can be 45 minutes if all the videos are viewed. This fulfills high-level requirement HR18 as the participant completed the game in less than 50 minutes. Thus, no changes were made in the game in order to make it shorter.

9.4 Testing with Target Group

The testing with the target group is the final evaluation of XploreIT. This evaluation will contribute to answering **RQ1.3** and find out if the approach of using a minigame-based serious game can increase teenage girls' awareness and interest in ICT.

9.4.1 Participants

The participants were recruited by contacting teachers from several lower secondary schools in Norway. In total, 15 schools were contacted through e-mail, where three schools were interested in participating. There were recruited respectively 3, 19, and 15 participants from those schools. Additionally, two participants were recruited through the researchers' network. Thus, in total, there were N=39 participants from the target group who tested the game. All participants were teenage girls in age 13-16 years old. An overview of the number of participants who attended each session can be found in Table 9.1, which also shows the participants' age. Before participating in the activity, all the participants' parents signed a consent form which can be found in Appendix D.4.

9.4.2 Questionnaires

Questionnaires were the chosen research tool, as it is well suited when one collects data from several people and when the data is brief and straightforward (Oates, 2006). The questionnaires used in this study are created with Nettskjema [1], which is software for creating questionnaires that protect the participants' identity and ensures their anonymity in their answers. Both questionnaires contain closed-ended questions using a 5-scale Likert to measure the degree of agreement or disagreement. Since the questionnaires have pre-defined answers, they must be well designed without ambiguous questions (Oates, 2006).

The questionnaire distributed pre-gameplay gather data about their experience with programming, games, and the participants' awareness and interest in ICT. The questions were included to get insight into changes related to the questions before and after playing the game. In addition, the results from the pre-questionnaire will be able to indicate if the participants are a representative selection of the target group. Except for collecting the participants' age, gender, and username, no personal data were collected. The username, age, and gender can not be used to identify the participants. The pre-questionnaire can be found in Appendix C.1.

[1] `https://nettskjema.no`

The questionnaire distributed post-gameplay was designed to collect data about their perception of ICT after they had played the game, their impression of the game, and the game's learning and entertainment value. Additionally, the questionnaire specifically asked the participants about their impression of the four main modules connected to the four learning goals of the game. These questions can be used to determine if some learning goals were better fulfilled and had a higher impact than others. In the post-questionnaire, images from the game are included to show each module's minigames. These images should remind the participants of the modules when answering the questions.

To be able to check if the game has changed their impression, the questionnaire contains questions similar to the pre-questionnaire. In particular, the participants are asked whether they are aware of and interested in ICT after having played the game, their thoughts regarding both genders in ICT and if they can picture themselves working with technology. The post-questionnaire can be found in Appendix C.2

9.5 Results

The results from the final evaluation will be divided into three parts: the observations, the results from the questionnaires, and the gameplay results. The observations made during the game activity sessions were limited to what was observed through the video-call, and consisted of comments and problems that might have occurred. The gameplay results were made available through the game development platform and showed how the players performed on each module. This section presents the results from these three data sources. The results will be discussed in Section 9.6.

9.5.1 Observations

In the first of the four game activity sessions, it was observed that participants collaborated in the beginning of the game. Two participants were observed watching

the introduction video in the first module together. However, all participants played the game individually on their computers. The players finished the game after approximately 30 minutes.

In the second session, participants were also observed collaborating and having conversations with each other. In particular, some participants sometimes discussed which answers were right or wrong. All participants played the game individually on their computers. This group played the game for around 30-40 minutes. The researchers observed that some girls showed excitement while playing the game, and in particular, one participant said out loud *"This is fun!"*.

The third game activity session was the most challenging to supervise. Firstly, during the introduction, it became clear that some of the girls missed some equipment that had to be retrieved before continuing. When this was fixed, the introduction was continued, and the pre-questionnaire was distributed. While answering the pre-questionnaire, one participant asked what IT is, and an explanation was provided to everyone. Additionally, one participant's game froze in the end, making it impossible for her to finish the session. In this game activity session, the participants did not collaborate in the same manner as in the earlier sessions. During the session, the participants had several questions regarding what to do, and the participants were not self-propelled compared to the previous participants. This group was challenging to give instructions to, and some participants did not answer the post-questionnaire, even though they were told to several times. There were only 12 complete results from this group, as three participants left without submitting the post-questionnaire. The session was a part of their last hour at school, and the participants had to use 15 minutes outside school hours to finish the activity. It was observed that the participants were agitated towards the end of the session.

In the last and fourth game activity session, the participants played the game together on the same computer but answered the questionnaires individually. One of the participants preferred to get the game activity instructions in English because she was not fluent in Norwegian. By playing the game together, the other participant could explain any language confusion in the game. After playing the game, they were asked if there were any language issues, and there were none. Also,

the participants mentioned that it was very informative and entertaining. However, they thought it was too much text sometimes and instead wanted to play more as the games were fun to play. There were no problems or challenges regarding the gameplay for this group.

9.5.2 Questionnaires

Data Cleaning

The number of girls participating in each session and how many of them answered both questionnaires is shown in Table 9.1. Before analyzing the results, the data set was cleaned because of dissonance in the number of responses in the pre- and post-questionnaire. Since the respondents had to write their usernames from the game in the pre- and post-questionnaire, the authors could find out where there were errors or dissonance.

Session	**Number of participants**	**Participants who answered both questionnaires**	**Age of participants**
Session 1	3	3	15-16 y/o
Session 2	19	18	14-15 y/o
Session 3	15	12	13-14 y/o
Session 4	2	2	14 and 15 y/o

Table 9.1: Overview of participants in each gameplay session

There were 40 submitted answers to the pre-questionnaire. One of the respondents had answered the pre-questionnaire twice. As the answers were identical, it was decided to remove one of them. After comparing the answers given to the pre- and post-questionnaire, it was discovered that some participants only had answered the pre-questionnaire. To make sure the pre- and post-questionnaire were aligned, the researchers decided to remove these participants' responses to the pre-questionnaire. The data cleaning of the pre-questionnaire is illustrated in Figure 9.1. After the data cleaning was complete, 35 responses laid the basis for the analysis.

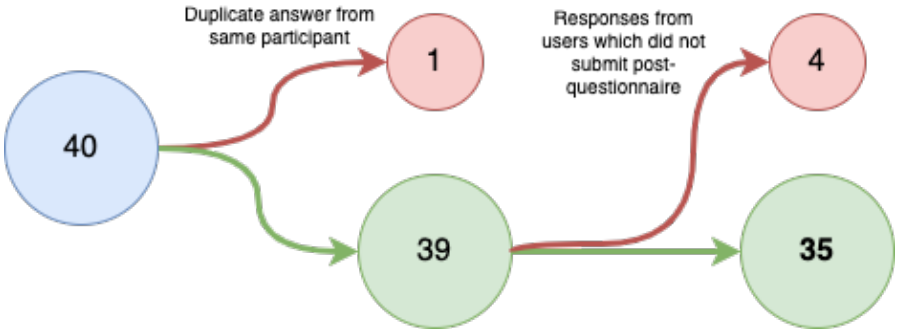


Figure 9.1: Data cleaning of pre-questionnaire

There were 35 responses to the post-questionnaire. After comparing the answers in the post-questionnaire with the gameplay statistics, it became clear that some respondents had evaluated modules they had not played. The authors decided to remove the responses from the modules where this was the case. Two participants had only played the Introduction- and Fight Stereotypes-module but evaluated all of the modules. Hence, their evaluation of module 3, 4, and 5 were removed. In addition, four players did not play the Boost Knowledge-module but had evaluated it. Therefore, these responses were removed. To sum up, the second module was evaluated by 35 respondents, 33 respondents evaluated module 3 and 4, and 29 evaluated module 5. However, all the participants' answers to the questions which did not regard a specific module were kept. The data cleaning of the post-questionnaire is illustrated in Figure 9.2.

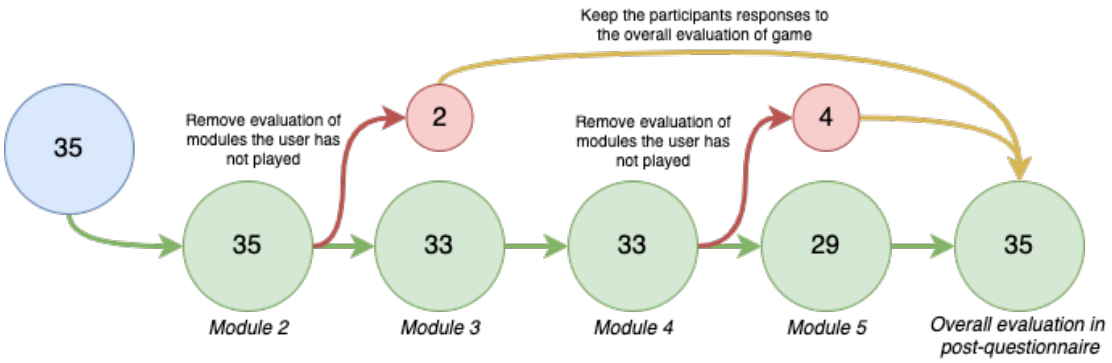


Figure 9.2: Data cleaning of post-questionnaire

Pre-questionnaire Results

After cleaning the data, there were 35 answers to the pre-questionnaire. The participants are 13-16 years old, and their age distribution is shown in Figure 9.3. Altogether, the participants cover all ages in lower secondary school.

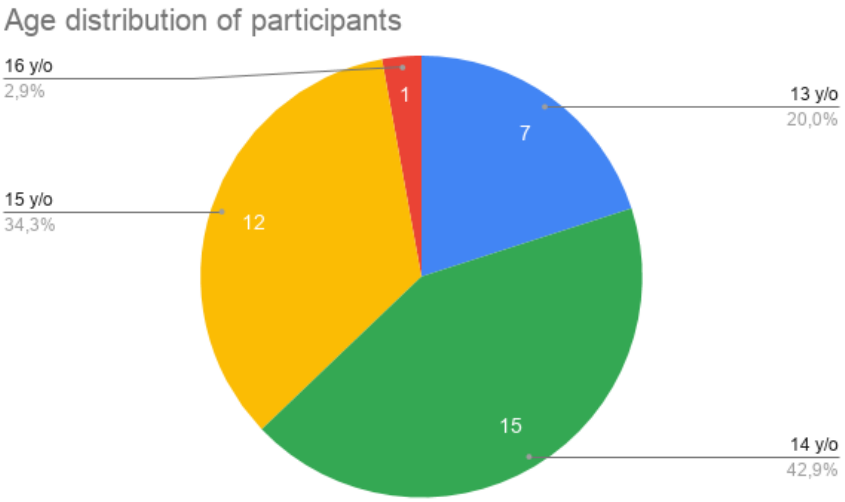


Figure 9.3: Age distribution of the participants

The average scores (AVG) and the standard deviation (SD) on all the questions in the pre-questionnaire are presented in Table 9.2. According to each statement, the table shows the results, with an associated statement ID used to refer to the different statements.

StatementID	Statement	AVG	SD
PREQ1	Do you like math?	2.91	1.17
PREQ2	Do you have experience with programming?	2.34	0.91
PREQ3	Do you play a lot of games?	3.46	1.24
PREQ4	I am aware of what ICT is	3.00	1.06
PREQ5	I am interested in ICT	2.74	0.98
PREQ6	I think that ICT and programming can be done by both boys and girls	4.71	0.57
PREQ7	I can picture myself working with technology	2.77	0.97

Table 9.2: Pre-questionnaire results: Average and Standard Deviation

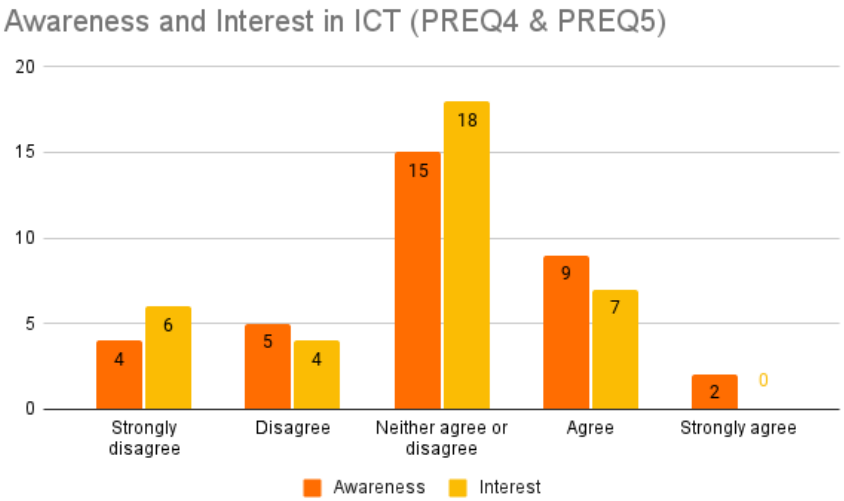


Figure 9.4: Distribution of answers on PREQ4 and PREQ5

When asked about their interest in mathematics and programming, the results show that some respondents disagree on liking mathematics (AVG=2.91, SD=1.17), with an average of 2.34 (SD=0.91) having programming experience. Some participants stated they play games often, but there is a great variation in the reported answers (AVG=3.46, SD=1.24). The answers regarding questions awareness and interest are shown in Figure 9.4. A total of 15 respondents report that they do not agree or disagree with being aware of what ICT is (AVG=3.00, SD=1.06). Most participants disagreed with being interested in ICT, only 7 of 35 (20%) respondents agreed to be interested in ICT, and 51% neither agreed nor disagreed. The participants seemed to believe that ICT and programming could be done by both girls and boys (PREQ6), with an average response of 4.71 (SD=0.57). A total of 27 participants strongly agreed to the statement, but only 17% of the respondents agreed or strongly agreed to picture themselves working with technology (AVG=2.77, SD=0.97).

Post-questionnaire Results

This section presents the results from the post-questionnaire. As described in Section 9.5.2, some cleaning of the post-questionnaires has been done. Thus, when

presenting the results from the post-questionnaire, all 35 responses will be used when addressing the general questions. However, when presenting the result from the questions regarding each specific module, only responses from players who played that module will be presented.

Fight Stereotypes

Thirty-five (N=35) respondents who submitted the post-questionnaire played this module. The average score and standard deviation of this module's evaluation are shown in Table 9.3. The content in this module was the one the players were most familiar with. It was also the module that the players reported the most awareness about ICT. However, it was also the module that could be considered the least interesting, as it had the lowest average score of all the modules, with 3.40. Still, it is a positive result, as it is higher than 3, which is the neutral score. The average value of the reported entertainment in this module is 3.60.

Fight Stereotypes			
StatementID	Statement	AVG	SD
M2Q1	I think this module was difficult	2.26	0.89
M2Q2	The content in this module was known to me	3.26	0.78
M2Q3	I think this module was entertaining	3.60	1.01
M2Q4	I feel that this module gave me awareness of ICT	4.20	0.90
M2Q5	I have become more interested in ICT after playing this module	3.40	1.01

Table 9.3: Results from Fight Stereotypes-module: Average and Standard Deviation

Promote Self-confidence

Thirty-three (N=33) of the participants who submitted answers regarding this module played it. The average score and standard deviation of this module's evaluation are shown in Table 9.4. The content in this module was the one the players were second most familiar with compared to the other modules. The average value of the awareness this module gave was 4.12, the same as the Provide Role Models-module. This is the module that the players thought increased their interest in ICT the most, with an average value of 3.52. Additionally, this module was the most entertaining among the players, with an average of 3.76. Further, this could

be seen as the easiest module, as it had the lowest average score and standard deviation compared to the other modules' results on MXQ1.

Promote Self-confidence			
StatementID	Statement	AVG	SD
M3Q1	I think this module was difficult	2.12	0.82
M3Q2	The content in this module was known to me	3.21	0.78
M3Q3	I think this module was entertaining	3.76	0.90
M3Q4	I feel that this module gave me awareness of ICT	4.12	0.74
M3Q5	I have become more interested in ICT after playing this module	3.52	1.06

Table 9.4: Results from Promote Self-confidence-module: Average and Standard Deviation

Provide Role Models

Similar to the previous module, thirty-three (N=33) participants who answered the post-questionnaire played this module. The average score and standard deviation of this module's evaluation is shown in Table 9.5. The content in this module was the one the players were the second least familiar with compared to the other modules. The average value of the awareness this module gave was 4.12, the same as the Promote Self-confidence-module. The players felt this module gave the second most increased interest in ICT after playing it. The average value of the felt entertainment this module gave was 3.64. The average score of the difficulty of this module can indicate that the players thought this module was the second hardest.

Provide Role Models			
StatementID	Statement	AVG	SD
M4Q1	I think this module was difficult	2.33	0.99
M4Q2	The content in this module was known to me	3.09	0.89
M4Q3	I think this module was entertaining	3.64	1.03
M4Q4	I feel that this module gave me awareness of ICT	4.12	0.74
M4Q5	I have become more interested in ICT after playing this module	3.45	1.00

Table 9.5: Results from Provide Role Models-module: Average and Standard Deviation

Boost Knowledge

Twenty-nine (N=29) participants who finished the Boost Knowledge-module answered the post-questionnaire. The average score and standard deviation of this module's evaluation are shown in Table 9.6. According to the average score, the content in this module was the one the players were the least familiar with. The average value of the awareness this module gave was 4.10, which was the lowest average score on this question. The players found this module to create the second least increased interest in ICT. The average value of the reported entertainment of this module was 3.45, which is the lowest of the modules. The average score of the difficulty of this module, with an average score of 2.41, can indicate that the players thought this module was the hardest.

Boost Knowledge			
StatementID	Statement	AVG	SD
M5Q1	I think this module was difficult	2.41	1.05
M5Q2	The content in this module was known to me	3.00	0.93
M5Q3	I think this module was entertaining	3.45	1.06
M5Q4	I feel that this module gave me awareness of ICT	4.10	0.67
M5Q5	I have become more interested in ICT after playing this module	3.41	1.05

Table 9.6: Results from Boost Knowledge-module: Average and Standard Deviation

Overall Impression

The results from the non-module specific questions regarding the game are presented in Table 9.7. Overall, the results show that participants have a good overall impression of the game (POSTQ1), with an average score of 3.94. The overview of the answers on POSTQ1 is shown in Figure 9.5, and the data suggests that most participants have a good impression of the game, as only one respondent reported the game was bad. The respondents also seem satisfied by the game's length (POSTQ2), as few respondents stated that it is too long or too short (AVG=3.31).

Learning Outcome

The average score and standard deviation of the questions related to the learning outcome (POSTQ3-Q6) are shown in Table 9.7. The results indicate that the

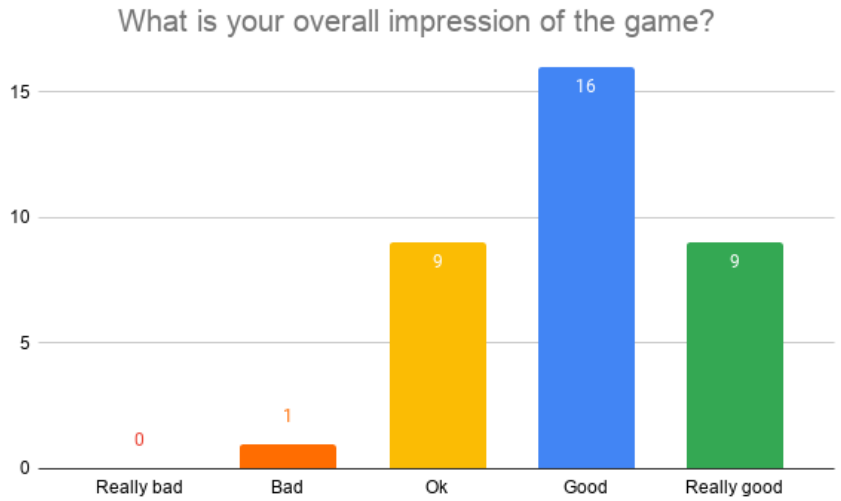


Figure 9.5: Distribution of answers on POSTQ1

participants thought they had received enough information to understand the tasks (POSTQ3) and that the solutions to each question were well-enough explained (POSTQ4). Further, nearly all players thought they had learned something about ICT from the game (POSTQ5), with an average score of 4.46. With a slightly lower score, 3.77, some girls learned something about programming by playing the game (POSTQ6).

Perception of ICT

The average score and standard deviation of the questions related to the players' perception about ICT (POSTQ7-Q11) are shown in Table 9.7. After playing the game, most girls were aware of what ICT is (POSTQ7), with an average score of 3.83. Fewer of the girls were interested in ICT (POSTQ8), with an average score of 3.26. However, only 3 of the girls were not interested, but many were unsure as 21 answered neither agree nor disagree. 80% of the girls thought ICT and programming could be done by both boys and girls (POSTQ9), with an average score of 4.46. After playing the game, nine people could not picture themselves working with technology (POSTQ10). However, nine girls could also picture themselves working with it, and 17 girls were unsure. Also, some girls wanted to explore ICT further after playing the game (POSTQ11), with an average score of 3.20.

StatementID	Statement	AVG	SD
POSTQ1	What is your overall impression of the game?	3.94	0.80
POSTQ2	What do you think of the length of the game? (1=too short, 5=too long)	3.31	0.72
POSTQ3	I think it was enough information to understand the tasks	3.97	0.82
POSTQ4	I think it was enough explanation of the solutions, so I could continue without being confused	3.97	0.75
POSTQ5	I have learned something about ICT by playing the game	4.06	0.80
POSTQ6	I have learned something about programming by playing the game	3.77	0.84
POSTQ7	I am aware of what ICT is after playing the game	3.83	0.66
POSTQ8	I am interest in ICT after playing the game	3.26	0.78
POSTQ9	I think ICT and programming can be done by both boys and girls after playing the game	4.46	0.95
POSTQ10	I can picture myself working with technology after playing the game	3.06	0.94
POSTQ11	I want to explore ICT further after playing the game	3.20	0.96

Table 9.7: Overall Post-results: Average and Standard Deviation

Comments from Participants

At the end of the post-questionnaire, the respondents had the opportunity to comment any additional feedback regarding the game. Only six participants provided additional feedback, and the feedback was mostly positive. Three participants commented that the game was good and fun. Another participant wrote that the game was very easy with good explanations overall. In particular, one participant commented: *I think the game was informative, and I have gotten a better understanding of what ICT is.* However, another participant commented the following: *I think it was too much text that made me lose interest in the game. I think it would have been more entertaining to have played more and if the animations were less realistic. In total, the game was really informative, but it could be boring at times.*

9.5.3 Gameplay

From the game development platform used, one can retrieve statistics from the gameplay. The gameplay statistics show how players have performed on each module, measured in stars. In addition, the players are ranked after how well they have performed. The maximum number of stars one can receive on a module is five stars. Table 9.8 shows an overview of the average number of stars the players

have received on each of the modules and the standard deviation. Only the players who have answered both questionnaires are included in this overview. Two players only played the Introduction- and the Fight Stereotypes-module, and four players did not play the Boost Knowledge- and Wrap-up-module. The number of players that played each module is included in the right column in Table 9.8.

Gameplay statistics				
Modules		AVG	SD	N
M1	Introduction	4.82	0.39	35
M2	Fight Stereotypes	3.79	0.84	35
M3	Promote Self-confidence	3.72	0.68	33
M4	Provide Role Models	3.63	0.55	33
M5	Boost Knowledge	3.21	0.50	29
M6	Wrap-up	3.79	0.96	29

Table 9.8: Overview of average number of stars and standard deviation for each module

From Table 9.8, it is clear that the Introduction-module is the module the players have received the highest average number of stars. Among the modules connected to the learning goals, the Fight Stereotypes-module has the highest average stars among all players (AVG=3.79, SD=0.84). Boost Knowledge-module is where players have received the lowest average number of stars (AVG=3.21, SD=0.5).

Overall, the average number of stars among all 29 players who played the whole game is 3.86. Among those 29 players, 13 players have an average higher than 3.86, and 16 players have lower than average.

9.6 Discussion

The following section will discuss the results from Section 9.5. By collecting the usernames in both questionnaires, a triangulation of the data sets from the pre- and post-questionnaire and the gameplay statistics is possible.

9.6.1 Level of Difficulty

In general, the post-questionnaire results show that the participants did not think the main modules (M2-M5) were difficult, as the reported average scores on **M2Q1**, **M3Q1**, **M4Q1** and **M5Q1** were all below 3.00. The average number of stars obtained by the players is over 3.00 in all modules. Thus, one can conclude that the difficulty in the game is not too high. On the contrary, the level is presumably not too low either, as it is only the Introduction-module that has an average of over four stars, which was intentionally designed as an easy module. The comments in the post-questionnaire support this. Some participants stated that the game was very easy with good explanations.

The module that is reported as most entertaining, the Promote Self-confidence-module, is also reported as the easiest module. Similarly, the module-specific questions and the average stars revealed that the most difficult module, Boost Knowledge, is the least entertaining module. Thus, this can indicate a connection between entertainment and difficulty, as the game is reported as not that entertaining when it is difficult. If the game had been too difficult or boring, the player might not have been able or motivated to complete all the modules. This would impact the player's awareness and interest in ICT, as all the learning goals of the game support the learning objective.

9.6.2 Awareness of ICT

In the comparison of the respondents' self-reported awareness of ICT before they played the game and after they had played the game in Figure 9.6, one can see an increased awareness among most players. In particular, the average awareness has increased from 3.00 to 3.83, and the standard deviation on POSTQ7 is 0.66 compared to 1.06 in PREQ4. Before playing the game, 11 respondents (31.4%) reported that they were aware of what ICT, while 26 players (74.2%) agreed to be aware of ICT after playing the game. That is an increase of 43%-points (15 more players) and a percentage increase of 236%. The comment from one of the participants saying that *the game was very informative, and I have gotten a better*

understanding of what IT is supports the findings of increased awareness of ICT among some players.

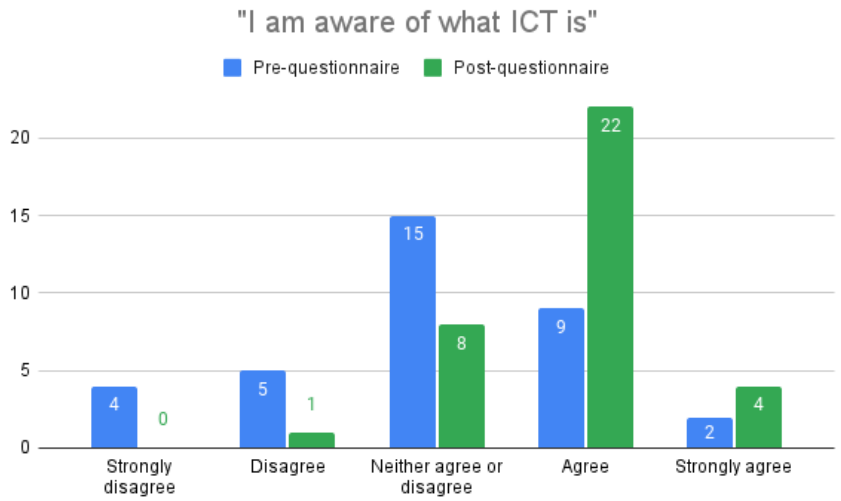


Figure 9.6: Awareness of ICT, a comparison of PREQ4 and POSTQ7

Looking into the module-specific questions regarding awareness, the Fight Stereotypes-module has the highest reported awareness with an average score of 4.20. The three remaining modules are respectively on an average score of 4.1, and all modules seem to contribute to increased awareness among the players equally. When comparing the gameplay statistics, the Fight Stereotypes-module has the highest average stars (3.79) among the four main modules. This indicates that there is a connection between performance and awareness, which will be further elaborated in Section 9.6.5. An interesting result is that the Fight Stereotypes-module, which is reported as the module giving most awareness to the player according to the post-questionnaire results, is also the module in which the content is most known.

To sum up, one can say that all four main modules have provided awareness of ICT to the player, and the game overall has promoted awareness of ICT to most of the players.

9.6.3 Interest in ICT

By comparing the players' interest in ICT before and after the game, one can see increased interest among the players. As Figure 9.7 shows, there is an increase of 11%, from 7 participants to 11 participants. being interested in ICT after having played XploreIT. The average score has increased from 2.74 to 3.26. The results addressing the general questions of the game (POSTQ1-Q11) contain the answers from all participants who played the game. However, 8 of the participants did not complete the whole game, which can have had an impact on their interest in ICT, as all the modules should work together to increase the player's interest.

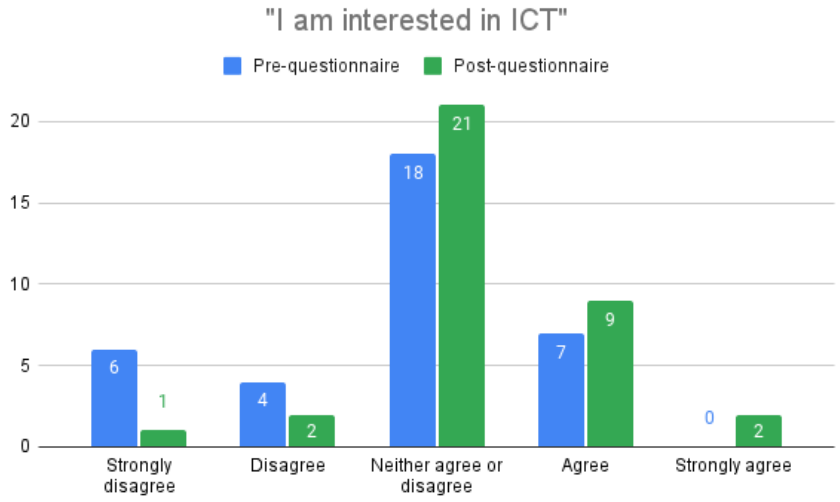


Figure 9.7: Interest in ICT, a comparison of PREQ5 and POSTQ8

Looking at the interest connected to each module from the post-questionnaire data set, the Promote Self-confidence-module has the highest average score (AVG=3.51). This module is also the most entertaining and least difficult. However, the average scores on all modules are between 3.40-3.51, so distinguishing the Promote Self-confidence-module as giving the most interest might not be correct. Thus, all modules have an average score of over 3.00, and players have reported an increase in interest by playing the modules.

An interesting finding is that the participant who reported that she was not able to watch any of the informing videos in the game has reported strongly disagree with being interested in ICT on all questions related to interest (**M2Q5**, **M3Q5**, **M4Q5**, **M5Q5** and **POSTQ8**) in the post-questionnaire. Looking into the gameplay results for this specific player, she finished the whole game, but the average stars in all modules are 3.5, which is lower than an average player with 3.82 stars. Thus, it seems essential to both play the whole game from the start until the end, as well as watch the videos, to have the best opportunities to increase the interest in ICT through playing XploreIT. Though it is worth mentioning that even though the rest of the participants have reported that they managed to watch the videos, this is not certain, one must believe in the self-reported answers.

9.6.4 Differences between Age Groups

A comparison between the age groups was made to see if there were any differences. When comparing the different age groups in this section, the groups will be addressed as the younger and older group. The younger group consists of the participants who are 13-14 years old, which are the majority of the participants (62.9%). The older group consists of the participants who are 15-16-years old and covers 37.2% of the participants.

There are interesting findings when comparing the two groups' performance in the game and their reported difficulty on the modules. Table 9.9 shows the average number of stars the two age groups have received on each module. The DIFF column shows the difference between the average number of stars of the older and the younger group.

According to the post-questionnaire results, the content in all modules was reported more familiar to the younger group than the older one. However, the older group thought that all modules except one were easier than the younger group. The youngest group reported that the Boost Knowledge-module was the most difficult, reflected in the number of stars they have received on the modules, where this module is the lowest (AVG=2.36). Both groups thought that this module had the least familiar content, but the older group performed better than the younger group,

Module		AVG 13/14	AVG 15/16	DIFF
M1	Introduction	4.77	4.92	0.15
M2	Fight Stereotypes	3.73	4.00	0.27
M3	Promote Self-confidence	3.41	3.77	0.36
M4	Provide Role Models	3.32	3.62	0.30
M5	Boost Knowledge	2.36	3.23	0.87
M6	Wrap-up	2.59	4.08	1.49

Table 9.9: Overview of average number of stars: A comparison of the age groups

with average stars of 3.23. This finding can indicate that the older group managed to absorb the knowledge and information presented in the Boost Knowledge-module and use it to solve the tasks, while the younger group had a harder time doing this.

The older group thought the Fight Stereotypes-module was the most difficult, while the younger group reported this module as the easiest. This module is, in fact, the module the older group performed best on, ignoring modules M1 and M6, with an average number of stars of 4.00. However, both groups thought that the Fight Stereotypes-module had the most familiar content. This finding can indicate that the stereotypes are deeper rooted in the older girls and harder to re-establish.

As expected, due to age differences, the older group has performed remarkably better on all modules, which is in line with the fact that the younger group reported that the modules were more difficult than the older girls. In addition, it was observed that several younger participants were impatient and did not concentrate at the end of the session. This observation could also be a reason for the results being weaker among the younger girls. However, the older girls are most likely more mature than the younger group, explaining the results.

A comparison of the results based on age indicates that XploreIT has increased the awareness of ICT among both age groups. Table 9.10 shows the changes from the pre- to post-questionnaire regarding the questions related to the players' perception of ICT and compares the two age groups. When comparing PREQ4 and POSTQ7, the findings indicate that XploreIT increased the awareness of the older group more than the younger group. However, the younger group has reported a higher awareness both before playing the game and after. When looking at the awareness

connected to the modules, the modules gave an average awareness of 4.23 among the younger group, while the older group reported an average score of 4.00. In the third gameplay session, one of the younger participants asked what IT was before answering the pre-questionnaire, indicating that some of the participants did not know ICT at all before playing the game. Thus, it is positive that XploreIT has increased the awareness of ICT among both groups, especially when some were unaware of the subject before playing the game.

Changes from pre- to post-questionnaire		**Age group 13/14**			**Age group 15/16**		
StatementID	Statement	PRE	POST	DIFF	PRE	POST	DIFF
PREQ4 POSTQ7	I am aware of what ICT is	3.09	3.86	0.77	2.85	3.77	0.92
PREQ5 POSTQ8	I am interested in ICT	2.95	3.32	0.36	2.38	3.15	0.77
PREQ6 POSTQ9	I think that ICT can be done by both boys and girls	4.77	4.32	-0.45	4.62	4.69	0.08
PREQ7 POSTQ10	I can picture myself working with technology	2.95	3.05	0.09	2.46	3.08	0.62

Table 9.10: A comparison of pre- and post-questionnaires, based on age

Similarly, XploreIT has influenced the older group's interest in ICT more than the younger group. On average, the older group reported that the modules gave an increased interest in ICT with a score of 3.60, while this number for the younger group is 3.34. The Boost Knowledge-module was the module the older group thought to have the most increased interest in ICT, with an average score of 3.69. As mentioned earlier, this module was reported as the most difficult one among the older group. The Boost Knowledge-module is the one the younger group thought gave the least increased interest in ICT, with 3.19 as the average reported score. As mentioned, the older group performed much better in this module. Thus, the self-efficacy connected to this module can have positively affected the older group, and the lack of self-efficacy can have negatively influenced the younger group.

The younger group thought that the Promote Self-confidence- and the Provide Role Models-module gave most increased interest in ICT, with an average score of 3.45. These modules were also the ones they found most entertaining, with an average score of 3.75. However, it is uncertain if there is a connection between entertainment

and interest, as the Boost Knowledge-module, which the older group thought was the most interesting, was the one they thought was the least entertaining.

Some of the youngest participants seem to have changed their minds about the possibility of both genders working in ICT when comparing PREQ6 and POSTQ9 in Table 9.10. The average score of 4.77 has decreased 9.43% to an average score of 4.32. Still, most girls are positive about this statement, but it is worth noting that the game can have made some players change their minds. Which mechanisms or minigames that might have had an impact on this change is not certain, but, as the gender expert stated in Chapter 4, when working for gender equality, one always runs the risk of reinforcing stereotypes, and that the most challenging learning goal to achieve was fighting stereotypes.

There is an increase in both age groups when the participants are asked if they can picture themselves working in ICT. When comparing PREQ7 and POSTQ10, XploreIT has influenced the girls to be more positive regarding technology studies. The increase is minimal in the younger group (3.4%), compared to an increase of 25% among the 15-16-year-old girls. This finding might be connected to the more significant increase of interest among the older girls than the younger girls.

As one can see in 9.10, the difference on all statements is higher for the older group than the younger, indicating that the game has had a higher impact on the oldest group on several aspects. However, it should be pointed out that the older group had a lower reported average on the pre-questionnaire than the younger group had, thus more basis to be influenced by the game. To sum up, XploreIT has increased the awareness and interest among both age groups, but the most among the older girls. Additionally, the older group has changed their attitudes towards being more positive about working within the technology field than the younger group has.

9.6.5 Differences in Gameplay Performance

The performance in the game can be connected to the game's impact on the players. The average number of achieved stars overall in the game was 3.86. To see if there are a connection between one's gameplay performance and one's questionnaire

responses, the responses were divided into the players who had performed below (N=16) and above (N=13) the average achieved stars.

The average age for the group performing below average was 14.25 (SD=0.93) and 14.31 (SD=0.75) for the group performing above. In the youngest group, 56% are below average, while 44% are above average. In the oldest group, 54% are below average, while 46% of the participants are over average in terms of stars.

	Performance below average		**Performance above average**		**Comparison**
StatementID	**AVG**	**SD**	**AVG**	**SD**	**DIFF AVG**
M2Q4	4.00	0.97	4.46	0.78	0.46
M3Q4	3.94	0.85	4.23	0.60	0.29
M4Q4	3.94	0.85	4.31	0.48	0.37
M5Q4	4.06	0.68	4.15	0.69	0.09
M2Q5	3.06	1.12	3.54	0.78	0.48
M3Q5	3.25	1.13	3.62	0.96	0.37
M4Q5	3.19	1.11	3.54	0.78	0.35
M5Q5	3.25	1.18	3.62	0.87	0.37

Table 9.11: A comparison of awareness and interest in ICT for all modules, based on gameplay performance

Table 9.11 shows how the respondents have answered the questions related to the awareness of and interest in ICT on each module, based on gameplay performance. Without exceptions, the players performing above average in the game had a greater average score on the questions "I feel that this module gave me awareness of ICT" (MXQ4) and "I have become more interested in ICT after playing this module" (MXQ5) on all modules, compared to the players performing below average. Also, there is less standard deviation between the answers from the group performing above average. This finding can indicate that the interest and awareness one gets from playing the game is connected to how well one performs.

As mentioned in Section 9.5.1, some of the students were agitated and impatient at the end of the session, which could have affected the results. If they had concentrated more on the minigames, they might have had a higher gameplay performance and, thus, a higher increased awareness and interest in ICT.

10 Discussion

This chapter discusses the different results from the main data sources gathered in this thesis. It compares the different findings from the final evaluation and draws parallels to the related work in Chapter 3.

10.1 Potential of Minigames to Increase Awareness and Interest in ICT

This thesis has explored the use of a minigame-based serious game to address the gender gap in Information and Communication Technology (ICT). This section discusses the potential of minigames to increase girls' awareness and interest in ICT based on the findings in this research.

Our research supports the findings in De Jans et al. (2017) and has shown that minigames are an effective and promising tool to raise awareness. From the results in Chapter 9, using minigames to promote ICT to teenage girls is a promising idea both in terms of increasing awareness and interest in ICT. XploreIT has increased the awareness and interest the most among the oldest participants (15-16 years old). Even though the increase is lower among the younger girls, they have higher reported awareness and interest in ICT after having played the game, which indicates an impact among this age group as well. One can see that the players who are performing above average report a higher increased awareness and interest in ICT after playing the game than the ones performing below average. The self-efficacy the girls get by playing the game can affect their interest in ICT. As stated in Güdel et al. (2019), self-efficacy is essential to fostering an interest in

technology, especially among girls. Thus, the game should not be too difficult. In the final evaluation of XploreIT, the youngest group thought the game was more difficult than the older group. However, the difficulty was not reported as too low or too high, which is important as an awareness-raising game should be playable by everyone (Saxegaard and Divitini, 2019).

One girl mentioned in the post-questionnaire that she thought the game could be boring at times, and wanted more minigames and less text to keep her interest throughout the game. This participant reported an increased awareness but no interest in ICT after the gameplay session. Thus, when designing minigames for increasing awareness and interest, the game must also be fun for the player. This can be done by including some minigames without learning aspects, as this can positively maintain the users' interest throughout the game (Saxegaard and Divitini, 2019). Another way to maintain the players' interest is by including learning material through various text, images, videos, and audio. Thus, to secure that minigames increase awareness and interest, one must balance the learning and the fun properly, as stated in (Arnab et al., 2021). To motivate and encourage the players throughout the game, the use of a female Non-player character (NPC), which also could act as a role model, is recommended.

Based on the experience with XploreIT, when creating a serious game with several learning goals, a suitable approach is to have one module for each learning goal. This approach is also used and supported by Arnab et al. (2021). Each module should contain several minigames that address its learning goal and support the overall learning objective. The modules can present information early in the minigame series, which is required in the next minigames, to cause a need for reflection on previously learned content. Additionally, one can address each learning goal from different angles through a series of minigames. This approach of addressing several learning goals in the same game through series of minigames leads to reflection and repetition (Frazer et al., 2007), which is beneficial in learning processes.

Similar to the game in Van Rosmalen et al. (2014), the modules in XploreIT must be played sequentially, as some learning goals are connected. For instance, the learning goal Promote Self-confidence was stated as dependent on Fight Stereotypes by the gender expert in Chapter 4. Thus, it was important to have played the

Fight Stereotypes-module before the Provide Self-confidence-module. By dividing the learning goals into modules, it is easier for the players to determine which learning goals are achieved and not. Further, this also makes it easier for them to distinguish the new knowledge acquired during the gameplay. Additionally, allowing the players to play the modules several times to improve their score is suitable for facilitating repetition. Summarized, it is recommended to separate the game into modules, each covering one learning goal, containing several minigames that should support that goal. Further, the modules should be played sequentially to support the overall learning objective.

For teachers who want to use such games in education, presence during the gameplay is essential to supervise the students. As described in Chapter 4, an important measure to provide role models to the target group is to be present during the gameplay. Thus, schools could invite external people who can act as role models further to support the game's impact on the target group. Additional material can be created to make the game more extensive and create different levels to challenge the players further.

Lastly, the game design guidelines from Akre-Aas et al. (2021), which was intended to support the design of serious games aiming to close the gender gap in ICT, have been included in the design of the serious game presented in this research. XploreIT consists of multiple different minigames separated into modules and includes several of the guidelines. The experience with the development of XploreIT suggests that minigames are a flexible and well-suited game type for including a majority of the guidelines, as they can be implemented in various minigames and different modules. Thus, this increases the potential minigames have at increasing girls' awareness and interest in ICT.

10.2 Game Design Guidelines

As mentioned in Section 2.1, the authors have, in earlier work, created game design guidelines aiming to address the gender gap in ICT. An example of how the guidelines from Akre-Aas et al. (2021) can be implemented and utilized is

demonstrated in this section by using the guidelines in XploreIT. Game designers can use these guidelines to support the design of games aiming to address the gender gap in ICT. Further, they could be used to improve existing games to attract more girls. The game in this research implements 10 of the 16 game design guidelines, and the findings illustrate how the game design guidelines have successfully influenced the design of XploreIT. In contrast to how the guidelines are presented in Section 8.2.3, this section presents them in the context of the different learning goals the guidelines aim to support.

Guidelines for Fighting Stereotypes

To help remove stereotypical images of programmers, a realistic game world with realistic avatars that shows the diversity in the field (G6) has been included. G6 is realized through using 3D avatars that the game platform provides and graphics from the real world, such as offices from the ICT-field. The avatars one can choose from have a wide range of skin tones, ages, and looks. This also fulfills G7, as the game has good graphics which combat the stereotypes. In addition, YouTube videos that show real-life examples from the ICT-field are included, which supports both G6 and G7. During the gameplay, the authors' presence could also have contributed to fighting stereotypes and showing diversity, as they represent young, female Computer Science students.

Guidelines for Promoting Self-confidence

Girls' lack of self-confidence is an issue, which could be addressed by promoting self-confidence through game elements. Positive rewards and achievements (G2) are included to increase the player's confidence during the gameplay. Additionally, to support G2, the minimum number of stars a player needs to receive an achievement on a module was lowered from 4 to 3 stars to increase their chance of receiving one. Further, positive feedback on the player's performance (G3) is integrated into the game in points and combo- and quick answer bonuses. In addition, the responses in the dialogue are designed to be encouraging and motivating, which

also could support G3. A game map, as shown in Figure 8.2 in Chapter 8 is utilized to visualize the status and the player's learning progress (G4). The player's achievement is also visible on the game map next to their respective module, which strengthens the impact of G2. The possibility of customizing it is recommended by G5a so that the player can identify with the avatar. The game platform does not support the customization of the player's avatar. However, the negative impact the absence of this guideline has is minimized, as the player most likely can identify with one of the 90 different predefined avatars.

Guidelines for Providing Role Models

The NPC in XploreIT is a female, non-stereotypical developer and is the main feedback provider in the game. She acts as both a role model and a motivator; hence G13 is fulfilled. Further, the gender expert emphasized the importance of providing role models and stated that the authors, as female computer science students, will be role models for the participants, as described in Section 4.4.3. Even though this is not a game design guideline, it contributes positively towards the learning goal. In addition, providing role models and fighting stereotypes is closely intertwined, as role models could help fight stereotypes. Thus, G13 could support both of these learning goals.

Guidelines for Boosting Knowledge

The learning objective of XploreIT is to increase girls' awareness and interest in ICT; hence G8 is fulfilled. This, combined with G9, problem solving tasks which facilitate learning programming, increases the players' knowledge about ICT. The problem-solving tasks are integrated into several of the minigames in XploreIT, and some minigames specifically focus on programming. Further, the game map visualizes the player's learning progress and shows an overview of how much and what knowledge the player has gained, which fulfills G4.

Additional guidelines

In addition to the guidelines supporting the learning goals, some guidelines should be included in games for girls in general. XploreIT does not include violent content nor sexualization of female characters, which fulfills G15 and G16. If violent content and sexualization of female characters are included, the game content could be considered offensive, which can negatively affect the learning goals and the learning objective.

For facilitating social interaction, G14 recommends collaborative gameplay. Since collaborative gameplay was not supported by the platform, combined with the social distancing recommendations related to Covid-19, the gameplay had to be done individually instead of collaborating in pairs. To incorporate some social interaction, the authors arranged each gameplay session in groups, which was successful, as it was observed that several of the girls collaborated during the gameplay sessions. The social interaction could help the girls to feel a belonging to the ICT-field and to fight stereotypes, as experiencing ICT with others could combat the misconception of ICT being an asocial field.

10.3 Design Process

The design process of XploreIT has been proved effective for designing a minigame-based serious game, with its many iterations on the design and the inclusion of different perspectives. The related work on frameworks, as described in Section 3.3, supports many of the chosen methods in this research. In De Jans et al. (2017), Van Rosmalen et al. (2014), and Zaman et al. (2012), experts were involved in the design process or in the evaluation. In this research, two different experts have been involved in different phases. Firstly, a gender expert was included to get insight into the impact on gender when designing a game. The gender expert and female technology students who participated in the workshop implicated high-level requirements for the game's design. Secondly, the first prototype was evaluated by a game expert, and the feedback given was used to secure well-designed minigames

and a serious game that supports the different learning goals. Overall, the design of XploreIT has been affected by different experts and different perspectives through the different iterations of the design to try to design the best possible game for this specific target group. Having two different experts in the different phases of the projects strengthens the final design.

The co-design workshop presented in Chapter 5 was developed by the authors and tailored for this research. Designing a workshop instead of using an existing workshop was done to secure that the workshop fulfilled its purpose and that the results could develop minigames for XploreIT. The different phases of the workshop are inspired by phases from the Design Sprint, which is a renowned method for solving complex problems throughout co-creation (Knapp et al., 2016). Another strength of the workshop is that it is highly adaptable. Without making any adaptions, it could be conducted with other participants than in this research. For instance, teachers can be included in creating and design minigames for their students. Further, by changing the learning goals in the workshop, one can address different problems, which also could be solved through co-creation. Lastly, one could easily add, adjust or remove the minigame templates in the workshop to make them suitable for other problems and needs.

Implementing the output from the design process into a well-functioning prototype was done utilizing a no-code game development platform. This design choice allowed the researchers to use most of their time to create a well-designed game that works towards its learning objective instead of creating the game from scratch. The authors recommend focusing on the problem rather than the development if the time of the project is limited.

Lastly, to evaluate the results from the design process, the target group has been included in the evaluation process of the game, as done in De Jans et al. (2017), Van Rosmalen et al. (2014), and Arnab et al. (2021). By including the target group, one can test whether the game is effective towards its purpose and audience. The target group was not included in the co-design workshop since De Jans et al. pointed out the risk connected to including them in design processes that concerns topics they are not consciously aware of. The pre-questionnaire showed that many girls were not aware of nor interested in ICT before playing the game. Therefore,

the results from the co-design workshop could have been unsuccessful if the target group had been included. The evaluation of the game was done through qualitative data from different sources, questionnaires, and gameplay, allowing triangulation of the data to secure the validity of the findings.

11 Conclusion

11.1 Summary of Results

The main contribution is to the area of serious games designed to close the gender gap in Information and Communication Technology (ICT). More specifically, this research aims to increase awareness and interest in ICT through the use of minigames, where the results could be found in: a related work section (Chapter 3), the design of the game XploreIT (Chapter 4, 5, 6, 7, 8), and the final evaluation and results of the game (Chapter 9). In addition, the co-design workshop (Chapter 5) can be used as a tool to design minigame content for specific learning goals. All together, insights from this research can be added to the knowledge base concerning the design of serious games aiming to close the gender gap in ICT.

11.2 Research Questions

The answers to the research questions and the main research goal that has been the foundation for this master's thesis are presented in this section. Overall, this research seeks to demonstrate how a minigame-based serious game can be designed to increase awareness and interest in ICT among teenage girls.

RQ1 *How can a minigame-based serious game be designed to increase awareness of and interest in ICT among female secondary school students?*

To answer the main question, one must address the answers to the sub-questions included throughout the chapters in this research. The design of XploreIT has

been iterated and evaluated multiple times to find out how such a game can be designed to increase awareness and interest in ICT. Thus, the design and evaluation of XploreIT have been described thoroughly in this thesis.

RQ1.1 *How can minigames be designed to fulfill the learning goals?*

Based on the related work and the gender expert interview, it was decided that the game should be separated into several minigames where each minigame work towards one of the learning goals. The related work found that creating a series of minigames to work towards the same learning goal could be a good approach. In that way, all four learning goals could easily be implemented in the game in separate modules. A co-design workshop was created to design the minigames, where female technology students combined a learning goal, a minigame template, and possibly some game design guidelines into a minigame that could fulfill the learning goal. The results from this workshop are examples of how minigames can be designed to fulfill the learning goals.

RQ1.2 *What kind of game content is most suitable for achieving the learning goals, and altogether increase awareness of and interest in ICT?*

The co-design workshop conducted with female university students laid the foundation for the game content. The result from the workshop was 16 minigame ideas with associated improvements. The minigame ideas from the workshop were then combined with the insights gathered in the interview with the gender expert to design the game content. The resulting game content was used in the first prototype, which the game expert evaluated. This evaluation influenced the final game, XploreIT. The full description of the game content can be found in Section 8.2.2.

RQ1.3 *To what extent does the minigame-based serious game increase female secondary school students' awareness of and interest in ICT?*

The final evaluation of XploreIT revealed that the minigame-based serious game increased the teenage girls' awareness and interest in ICT. Among the target group of this research, the awareness and interest increased the most among the oldest teenagers, the 15-16-year-old girls, compared to the 13-14-year-old girls. However,

the game has increased the awareness and interest in ICT among both age groups. Further, findings show that the awareness and interest also increased more among the players who performed well in the game, perhaps due to increased self-efficacy. All in all, the use of minigames seems to be a promising approach for increase female secondary school students' awareness of and interest in ICT, which further can contribute to closing the gender gap in ICT.

11.3 Strengths and Limitations

The findings in this research are based on a triangulation of data from different data collection methods. A quantitative evaluation with a game expert was conducted on the first prototype to ensure high quality. The final evaluation with the target group is based on quantitative data through questionnaires and gameplay data to assess the impact XploreIT had on teenage girls in terms of increased awareness and interest in ICT. The triangulation of the data from the final evaluation improved the validity of the findings presented earlier in this research. Additionally, the evaluation of the game was done with a satisfying number of responses from girls within the ages of 13-16 years after cleaning the data set. To secure the reliability of the results, the authors have analyzed the results in parallel.

As discussed in Section 10.3, another strength of this research is the many perspectives that have implicated the final design of XploreIT, with both a gender expert, game expert, and female technology students. These perspectives have implicated the design in different iterations and evaluations of the design.

A limitation of this study is that the scales for the impact the game has had are based on self-reported data and no external measurement. Therefore, it only measures how the target group perceives their learning outcome after playing the game, instead of measuring their actual awareness of and interest in ICT. Even though some participants did not answer the post-questionnaire or answered questions for modules they did not play, these data were cleaned out from the final dataset to minimize the risk of misleading responses.

Another limitation is that the research in this paper only investigated the short-term effects of XploreIT. The short intervention time for the gameplay is not enough to measure an absolute increase of awareness or interest among the players. However, this was never the purpose of the research, but more investigating the potential of doing so with minigames. Awareness of and interest in ICT is something that could be measured over a more extended period to see the actual impact and change the game has had. Therefore, future research could examine the long-term effects of a serious minigame aiming to increase the awareness of and interest in ICT, as the game also could have delayed effects.

11.4 Recommendations for Future Work

Even though XploreIT was designed and intended for teenage girls, it would be interesting to test the impact the game has on teenage boys as well in future work. As stated by the game expert in Chapter 7, the design of XploreIT is not excluding boys in any way, and the game could be interesting for them as well. Though this was not the primary focus for this research, it is possible in future work. Additionally, it could be worth noting for future work that targeting 11-12-year old girls is interesting for this problem, as mentioned by the gender expert in Chapter 4.

As XploreIT is only a prototype, expanding the game with several other levels is possible. In that way, the game can be suitable for several ages, where the difficulty can be adjusted according to the player's preferences or age. If the game is expanded, an interesting approach is to evaluate the game with the target group over a more extended period than done in this research. For instance, an intervention span of several weeks could have been interesting, and to measure long-term interest and in ICT among the participants. Then, the participants could have played the game in their spare time whenever and as much as they wanted.

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Fighting the Gender Gap in ICT

Guidelines for game design

DRAFT

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- **Abstract.** Girls and women are still under-represented in ICT, both in education and the tech industry. In this paper we investigate how to design games for teenager girls to address the identified gender gap. Based on existing knowledge about this societal challenge, we identify 4 learning goals that games can address: Promote Self-confidence; Fight Gender Stereotypes; Boost Subject Knowledge; and Provide Role Models. In addition, based on a systematic literature review, we identify game elements that are reported in previous research as having a positive impact on girls' game experience. The learning goals and game elements are summarized in a set of 16 design guidelines. The design guidelines are intended for game designers and developers. In addition, they might be used by educators to reflect on the games to introduce in their classes.

Keywords: Game Design, Gender Gap in ICT

1 Introduction

The limited number of women in Information and Communication Technology (ICT), both in education and work, is a well-known problem [1, 2]. The increased digitalization of work and society is making this gap even more problematic and, as a result, a growing number of initiatives are addressing this issue. Many of these initiatives are targeting teenagers with the awareness that the gender gap in ICT must be addressed during school years. These initiatives are often involving complex learning ecosystems. For example, public and private bodies are organizing programming camps for girls; university and industry are offering to bring role models into schools.

Games have been proposed as one of the tools to help fighting the gender gap among teenager and as a promising approach to improve girls' attitudes regarding pursuing a career in computer science [3, 4]. However, it is important to remember that girls and boys have different preferences related to games [5]. For instance, [6] reports that girls prefer games with collaboration, while boys tend to prefer competition and individual play. These differences are important to take into account when designing games, but this body of knowledge is not easily available.

Contributing to this body of literature. the research question addressed in this paper is *How to design games that can help to address the gender gap in ICT among teenagers?* The paper contributes to the existing literature by providing a set of guidelines to support the design of games to fight the gender gap in ICT.

The paper starts by presenting four learning objectives that can be integrated in games to help fight the gender gap in ICT. Section 3 presents the results of a systematic literature review to identify relevant game elements. Section 4 brings together the learning objectives and game elements to create a set of guidelines. Section 5 presents a scenario of use for the guidelines and Section 6 concludes the paper.

2 Learning goals of the game

Different factors influence the gender gap in ICT. Based on existing literature on challenges to women involvement with ICT, we identify 4 main learning goals that games can address to help fighting the gender gap. These goals are closely connected, and they are distinguished mainly for analytical purposes. They are not intended to necessarily co-exist in the same game or to be addressed at the same level. They are mainly intended to create awareness that games can do more that helping girls to learn programming and help designers to adopt a broader perspective on the potentials of games.

LG1. Promote Self-Confidence. A critical issue in the early stage of the gender gap in ICT is the lack of confidence in one's own abilities. Some girls are undervaluing their achievements and think that they are unable to compete with boys in school because they believe that boys are better in STEM subjects than they are [8]. Girls will not pursue an ICT career if they believe that they won't succeed in it [9]. For example, studies of coding club shows that lack of confidence might be one of the reasons causing low participation [10].It is therefore important that a game to fight the gender gap is considering this issue and aims at improving girls´ self-confidence.

LG2. Fight Gender Stereotypes. To assume that men are more suited for scientific work, and that boys are better than girls in STEM, contributes to gender stereotypes, already in elementary schools [11, 12]. Gender stereotypes are highly connected to lack of confidence. When designing games, it is paramount to avoid confirming these stereotypes, but also design explicitly to increase in the player the awareness about the existence of these stereotypes and developing strategies to cope with them.

LG3. Promote Subject Knowledge. Girls' reluctance to engage with ICT might lead to a knowledge gap that is difficult to address while progressing with studies. For example, girls who have not attended school or extra-curricular activities for learning programming early in their studies, might face a barrier when selecting more advanced courses. However, the problem does not only connect to lack of knowledge of the concepts and tools of ICT. Often, it connects more generally to the lack of understanding of what the field is and subject stereotypes. For example, in the interviews reported in [13], female secondary school students stated that they wished to help people in their future profession. Unfortunately, no one thought this was possible with ICT. Similar results are reported in a study by Microsoft [14]. In the same study, 9 out of 10 girls described themselves as creative. However, only 37% of the girls associated STEM

professions with something that involves creativity. Summarizing, when designing a game to fight the gender gap, promoting subject knowledge has to be carefully considered, addressing different perspectives. Promote subject knowledge is not only related to teaching programming, but also to help the players to understand the field, including its social impact and creative nature.

LG4. Provide Role Models. The considerable gender gap in STEM, and ICT in particular, leads to the lack for many girls of role models they can relate to. This is critical because role models can inspire girls and eventually increase their interest in engaging with the subject [9, 15]. A game might help increase awareness about role models by providing for example information about or access to potential role models.

3 Game elements for girls

In this chapter we present a review of the literature to identify the game elements that can help to design games that are suitable for girls.

3.1 Method Description

The goal of the literature review is to understand which game elements are known to promote the design of games that girls enjoy. The databases searched were IEEE Xplore, ACM digital library, Elsevier's Science Direct, Scopus, and ISI Web of Science. After some calibration, the final query was: ("game design" OR "game elements" OR "serious games") AND (girl* OR teen* OR youth* OR female* OR gender*). The search resulted in 1707 articles (IEEE:114; ACM: 68, Elsevier's Science Direct: 48; Scopus: 1041; and ISI Web of Science: 463). The following eligibility criteria were defined for the screening of the papers:

- Report Eligibility - RE1: The publication must be in English; RE2: The publication must have an abstract ; RE3: The publication must be published in 2010 or later; RE4: The publication should be published in international conferences, peer-reviewed journals, or as book chapters; RE5: The study must be accessible in full-text without any fee
- Study Eligibility - SE1: The publication must include a study of girls or gender differences among children; SE2: The publication must evaluate a game design or game elements or be a literature review on the topic

To promote internal validity two of the authors screened a first set of 50 papers to make sure that the criteria are applied consistently. After checking the compatibility of the screening on this first set, the two authors proceeded separately dividing the remaining papers. The screening was first done on title and abstract, resulting in 99 papers. Both authors have then done the screening of these papers based on full text. This phase resulted in 24 relevant papers, 8 literature reviews and 16 research papers.
The identified existing literature reviews are not analyzed here in details. It is however worth to mention three of them that are relevant for the study and that are used in shaping our guidelines. Schwarz et al. [16] focuses on literature that is associated with user

engagement in games for promoting healthy lifestyles among teenagers. Analysing 60 studies, the review identifies several game elements to create engagement among youths. Even though most game elements are described regardless of gender, some gender differences were pointed out [16]. Alserri et al. [17] analysed the existing literature on promoting higher female participation in Science, Technology, Engineering, and Mathematics (STEM), extracting 20 game elements matching with gender preferences in digital games. However, the target group for the games is not specified. Sharma et al. [4] presents a literature review that investigates the relationship between game playing or design activities and girls' perception of Computer Science as a career choice. The systematic literature review's key conclusions are that ICT games for girls require personalization, an opportunity for collaboration. and the presence of a female lead character. However, the authors point out that the strength of evidence is low as the time span of the interventions, and evaluation was limited. Therefore, no other specific advice to game and activity designers were offered.

A common issue in the existing literature reviews is that the studies they examine lack an explicit evaluation of the game elements. By taking into account the lessons learned from the identifies reviews, and narrowing down the search to fit our target group, we aim to contribute with knowledge on which game elements that are known to have an impact on teenagers girls.

3.2 Identifying game elements

The 16 papers identified after the screening of the search results were analyzed using the mechanics-dynamics-aesthetics MDA-framework [18]. The same framework is adopted for analysis also in [16], with the difference that their analysis does not focus on gender issues. (To ensure reliability in the process, the articles were coded independently by two of the two authors. After comparing the coding, all divergencies were discussed to reach an agreement.) The MDA-framework can be used to analyse games by breaking the game elements into three categories. *Mechanics* describe the particular components of the game, at the level of data representation and algorithms. Together with the game content, it supports the overall gameplay dynamics. An example of a mechanic is a level. *Dynamics* describe the run-time behaviour, the interaction, between the users and the mechanics of the game. Besides, dynamics support the creation of aesthetic experiences. For instance, rewards can create a surprise experience, which is an aesthetic. The *aesthetics* describe the emotional response in the player when playing the game. Considering space limitations, we do not provide an overview of the single papers, but we report only the analysis following the MDA-framework.

Mechanics. Six of the MDA-framework mechanics were identified in the papers.

- **Avatar.** Avatar is the game mechanic discussed most frequently, including fantasy and animal characters [19, 20] as well as, in the majority of papers, more realistic ones [3, 21–24, 24]. Furthermore, the importance of a player's resemblance and identification with the avatar was found in both [23] and [25]. This is also supported by the findings on the dynamic component Self-expression. We summarize with ***M1:***

Realistic avatars in games, which the players can relate to or identify with, and ***M2:*** *Sexualisation of female characters should be avoided*.

- **Hints.** [22, 26, 27] include hints in their game. Also, [24] recommends implementing mechanisms to strengthen self-efficacy in mastering technology tasks. Hints could be useful to prevent girls from feeling lost or defeated if they are stuck on a task. Even though there is not much evidence on hints nor on how they should be designed, we suggest to attempt **M3**: *Incorporate hints in the game*, since strengthening girls' self-efficacy is important to secure their enjoyment of the game.
- **Status and rewards.** Five papers [20, 22, 24, 27, 28] use levels in the game or evaluates this as a positive element. Further, three of these suggest that the difficulty should increase as one advances [22, 24, 27]. Based on these findings, we suggest **M4**: *Use levels in games and make the difficulty increasing throughout the levels*. However, there should be **M4a**: *A mechanic for switching between game levels* [28], or **M4b**: *The possibility of getting help when the player needs it* [27], so the challenge does not weaken girls' confidence. The most common mechanic to use as rewards were points. However, other mechanics like stars and positive encouragement was also found in [27]. Therefore, there is no clear pattern for how rewards should be fulfilled. Still, we argue that **M5**: *Rewards should be incorporated to encourage and reward the player*, to motivate and increase girls' confidence.
- **Devices & Game Control.** The analyzed papers do not support any conclusion on these two mechanics.

Dynamics. After analysing the papers, seven different game dynamics were identified.

- **Guidance.** Guidance was used in different ways in five papers. Dele-Ajayi et al. [22] provided the participants with a step-by-step guide booklet but found that the children preferred to experiment and try their own way of doing things. Textual guidance in the form of signposts or instructions attached were rare in the games created by the children in [26]. However, around half of the games contained some sort of instruction in conversations, paths or clues in the landscape. de Vette et al. [29] state that the games should be sufficiently challenging because it can enable achievement. At the same time, promoting self-efficacy is important to avoid players to get stuck [24]. Hints that players can access when they need it might be a useful element, as used in [24, 27]. Summarizing we suggest, **D1**: *Hints as the mechanism to fulfil the guidance dynamic*. By using hints, the players won't get step-by-step guidance, but still be able to access help if needed, to secure confidence.
- **Feedback.** Feedbacks can be associated with something positive, like achievements [24, 29]. Robertson [26] found that girls were more interested in receiving feedback than boys, and Emembolu et al. [3] found that girls were more likely to take some action in response to comments than boys. The latter also propose that this is possibly explaining why their final products were rated more highly. Hence we conclude that both positive and constructive feedback is suitable in games for girls: **D2**: *Positive feedback to increase the motivation*, and **D3**: *Constructive feedback to increase the learning outcome* should be included.
- **Self-expression.** Self-expression was identified in six of the papers and realised through the player's resemblance or identification with the main character. To be

able to fulfil a player's identification with an avatar, there has to be a possibility of customising the avatar or choosing among a variety of pre-made avatars. The advantage of the first solution is that the resemblance will be closer to the actual person and the player will have the ability to make the character how she wants. However, this demands more resources in terms of development, so it is a choice that has to be considered. In the game used in [23], the female participants had difficulties of identifying with the game characters provided. This finding indicates that choosing among a variety of avatars might not be sufficient for securing self-expression in a game. Therefore, we will encourage to implement **D4**: *The possibility of customising the avatars*, which includes both the main character and other important avatars, as the latter have been suggested in [25]. In addition to be able to choose how an avatar looks, [21] points out that one also should pay attention to a girl's ethnicity, interest and motivation.

- **Status.** Only few papers state explicitly something regarding the game's status, therefore it's hard to conclude on an appropriate mechanic. However, several of the games used levels, which could be a suitable mechanic for the status. Therefore, we suggest using **D5**: *Levels for indicating the status of the game*, but we stress that this might not be the right element for all kinds of games.
- **Goal.** Only four papers included a goal in their game. If a serious game is developed, the literature suggests that the learning objective should be the goal, as it is in [24, 25, 27]. Besides this, little can be said about the goal of the game from the literature provided. Thus, we summarize **D6**: *If serious game: learning objective as the goal of the game*.
- **Achievements and Rewards.** As discussed, self-efficacy and confidence is important for girls. It can be supported with positive achievements and rewards. de Vette et al. [29] suggest to "provide content that enables achievement", like content that can be unlocked, to challenge the player continuously. Other games provide positive encouragement, points, stars or positive feedback [20, 22, 27]. We suggest that **D7**: *Positive achievements and rewards* to be incorporated in the game.

Aesthetics. 7 categories were identified in the articles.

- **Sensation.** There were many suggestions in the articles, ranging from a total pink girl game [19], to other color schemes. Thus, no clear pattern is found regarding sensation. However, it seems important that the graphics are designed wisely when designing for girls, as it is an important game feature for female players [20, 28]. Hence, the aesthetic **A1**: *The game should have high-quality graphics*.
- **Fantasy.** A realistic context seems to be popular among girls [6, 24, 25]. Similarly, Speiler and Slany [20] found that girls liked nature-themed graphics. However, the type of game world is tightly connected to the context of the game and should be designed accordingly. This leads to the aesthetic **A2**: *Realistic game world*.
- **Narrative.** It seems like violent content is disliked by female players, as it is mentioned in five of the articles in this review. Additionally, two articles proposes that the narrative is an important game aesthetic for girls [20, 28]. This resulted in the aesthetic suggestion is **A3**: *Non-violent content*.

- **Challenge.** Girls preferred different types of challenges. Some articles state that girls liked puzzles [20, 30], while others stated that puzzles were disliked most, and memory games were the most popular with girls [28]. Despite that, it seems evident that problem solving is a fun game element among girls. The aesthetic **A4**: *Include problem solving tasks* was therefore created.
- **Fellowship.** Some of the papers suggest that a collaborative game approach is good for girls [6, 25, 27]. Additionally, Cunningham [21]stated that girls did not like competitive games. On the other hand, de Vette et al. [29]state that both competition and collaboration can be engaging for both genders, and that children, in general, like to play together. Social interaction is also proposed. A clear conclusion regarding fellowship cannot be stated. There are arguments for both collaborative and competitive games. However, it seems important to include social interaction in the game. A consequence of this is that the game can ***A5****: Include collaborative or competitive aspects,* but that it should ***A6****: Include social interaction*.
- **Discovery & Expression.** Though these game elements were mentioned, the analyzed papers do not support any conclusion about them.

4 Design guidelines

This section discusses how the implications summarized from the literature review can help to design games that meet the identified learning goals (Section2), crystalizing this information into a set of guidelines.

Promote self-confidence. In order to gain confidence through the game, game mechanics such as hints (M3), levels (M4), and rewards (M5) can be included. Getting stuck in the game can decrease confidence, and discourage the player. Providing guidance (D1) in the form of hints so that the player can move forward can prevent this from happening (M4b). Additionally, including positive rewards or achievements can create confidence. The dynamic game element feedback can also increase a player's confidence by providing positive feedback (D2) on the player's performance. Including some status (D5) in the game can also have a positive effect on the player's confidence, as it provides a clear overview and visualisation of the progression in the game. However, if the player does not understand the game, the lack of positive feedback can create low confidence, so levels might be useful to prevent that. Using levels with increasing difficulty can also increase confidence, as the player can choose to play the level that corresponds to her abilities. The dynamic self-expression (D4) could also be used to increase a players confidence. By designing an avatar (M1) which one could identify with, the sense of achievement after mastering tasks can increase, since the player can see herself doing the tasks.

To conclude, the guidelines to promote self-confidence in ICT are: **G1a**: Guidance through hints to proceed in the game; **G2**: Positive rewards or achievements: to increase confidence; **G3**: Positive feedback on player's performance; **G4**: Status as a visualisation of learning progression; and **G5a**: Customisation of the player's avatar to identify with the avatar.

Fight Gender Stereotypes. To fight the stereotypes in ICT, including a realistic game world with realistic avatars (A2) with the presence of all types of programmers, from female programmers to the nerdy boys, can show the diversity that actually exists in the field. Further, graphics (A1) is identified as an important aesthetic for girls. The graphics can be utilised to showcase a diversity of people. It was found that self-expression was an important game dynamic, which could be fulfilled through the customisation of a player's avatar (D4). This could contribute to disproving the assumptions about stereotypes, by including an avatar which one resembles or identifies (M1) within the game.

In conclusion, the game elements that can help fighting stereotypes are: **G6**: Realistic game world with realistic avatars that shows the diversity in the field; **G7**: Good graphics which combat the stereotypes; **G5b**: Customisation of the player's avatar to remove stereotypical images of programmers.

Boost Subject Knowledge. Similarly to the game elements used to promote self-confidence, hints (M3), learning goal (D6) and constructive feedback (D3) can have a positive effect to boost knowledge. Firstly, it might be useful to consider games that facilitate learning programming, as recommended in [4, 17] to promote interest in STEM careers. The game can create awareness and possibly increase the player's knowledge of ICT through problem-solving tasks (A4), possibly focusing on the societal impact and relevance of ICT. As described in Section 2, most girls did not associate STEM jobs with creative tasks. Thus, even if the literature review has not identified creativity as an issue, it might be useful to integrate in the game creative tasks to rectify the impression that many girls have. Additionally, guidance (D1) in the form of hints can provide the necessary knowledge for the player to proceed with the tasks. The hints can, for instance, contain descriptions of unknown concepts to the player. Giving constructive feedback can also help the player to reflect, which is associated with increased knowledge. Lastly, including a status (D5) in the game can be a visualisation on how much knowledge the player has gained.

The guidelines to boost the knowledge of the player are: **G8**: Learning programming as focus of the game; **G9**: Problem-solving tasks to facilitate learning programming, with focus on the societal impact and relevance of ICT; **G10**: Incorporation of creative tasks; **G1b**: Guidance through hints for assistance in the game; **G11**: Constructive feedback on tasks with the goal of triggering reflection; **G4**.

Provide Role Models. In the literature, we found that girls would benefit having role models. Role models could be female teachers, parents or other female role models in STEM. Both positive (D2) and constructive (D3) feedback was found to be an effective game dynamic. Further, Spangenberger et al. (2019a) found that non-player characters play a crucial role as girls' feedback providers. Therefore, we suggest using role models as feedback providers. Also, girls want to make their own choices regarding characters. Thus, a spectre of role models to chose between (D4) would be suitable, so the player could choose the one she identifies with (M1) or admire the most as her feedback provider. Having a role model as the feedback provider could also be used to fight stereotypes. To conclude, the guidelines for providing role models are: **G12**: Non-player-character: Design a range of avatars that the player can choose to be the Non-

player characters (NPC); **G13**: Feedback provider: Use the selected NPC. Design so that the NPC can act as a role model and motivator

In addition, there are three guidelines that are more general. To prevent isolation, playing a collaborative (**A5**) game could create a feeling of being included. By letting the girls play with other girls, they can get a feeling of belonging in the ICT field together through social interaction(**A6**) with each other. Providing social interaction can also fight stereotypes, as some think that being a programmer is an asocial profession. Thus, the guideline to facilitate social interaction will be the following: **G14**: Collaborative gameplay. We found that non-violent content (**A3**), in addition to the sexualisation of female characters (**M2**), should be avoided as there were strong indications against it. Therefore, two more guidelines will be applied, which are: **G15**: Non-violent content; **G16**: Avoid sexualisation of female characters

5 Using the guidelines to compare programming games

Design guidelines are primarily intended as a tool for game designers and developers in supporting the creation of games. However, the guidelines could also be used by educators to compare and reflect on programming games and support them in selecting games to be used in their activities. Let us illustrate this use with two examples. Consider two rather popular programming games: CodeCombat (https://codecombat.com) and CodeMonkey (https://codemonkey.com).

CodeCombat is based on teaching text-based-programming through a number of tasks with increasing difficulty in a game world. CodeCombat is specifically designed for use in a class-context, where the teacher can get an overview of the progress of each student. CodeCombat fulfills approximately six of the 16 guidelines. The game has hints, rewards and achievements, status and thus fulfilling G1, G2 and G3. The player can change avatar, but not promoting full identification. In particular, the available avatars will not remove stereotypical images of programmers, they will more likely strengthen them (G5b). However, the game has problem-solving tasks to facilitate learning programming G9, as well as providing constructive feedback to trigger reflection as in G11. So, though the game might be a useful tool to learn programming, there are some concerns about its design when it comes to promote girls´ participation. This is in line with existing research reporting that girls did not feel welcome in the masculine game environment in CodeCombat [23].

CodeMonkey (https://codemonkey.com), is a platform offering different games. Among others, it contains games which have text-based, block-based and Python-based courses. Because of the different difficulty levels, no previous coding experience is needed to start playing on the platform. Courses are designed for school, extra-curriculum or home-use. In addition to offer a learning platform for individuals, a class-context is offered, where teachers have the possibility of following the students' progress. The game fulfills multiple of the guidelines, to sum up: G1, G2, G3, G4, G9, G10, G15, and G16. Before playing the game, an avatar has to be chosen. The different avatars range from animals to humans, in different shapes and looks. Therefore, on

could identify with the avatar (G5a) and remove the stereotypical images of programmers (G5b). However, this avatar is almost invisible in the game. Only a small picture of it is visible in the top right corner, where you can click it to access the profile. Therefore, since the avatar the player chose is not the main player-character, G5 cannot be seen as achieved. Since the game unfolds in a jungle environment, the realistic game world described in G6 is not achieved. Moreover, the graphics are good, but do not combat stereotypes, hence G7 is not followed. The game evolves around teaching programming, not about awareness of ICT, therefore G8 is not fulfilled. Two students could collaborate on solving the tasks, but there does not exist a built-in function that facilitates for students to play online together, hence G14 is not followed.

This assessment is not intended to exclude any game from the set of tools adopted by educators. However, an understanding of the flaws in the design with respect to gender might increase awareness of teachers and push them to introduce corrective actions to compensate for the limitations. It should also be noted that most of the commercial games are focusing on learning programming. Educators should consider integrating with other games or activities that address more directly the other learning goals identified in Section 2. For example, the game described in [31] does not aim at teaching programming, but rather focuses on a game concept aiming at explaining the role that technology plays in everyday life, fighting stereotypes connected to ICT.

6 Conclusions

The paper contributes to the body of literature on games for addressing the gender gap in ICT. Based on existing knowledge about this societal challenge, we identify 4 learning goals that games can address: Promote self-confidence; Fight Gender Stereotypes; Boost Subject Knowledge; and Provide Role Models. In addition, based on a systematic literature review, we identify game elements that are reported in previous research as having a positive impact on girls' game experience. The learning goals and game elements are summarized in a set of 16 design guidelines.

The guidelines are not prescriptive and are mainly intended as a way to summarize existing knowledge in the field. Future research is aiming at identifying how to integrate the various guidelines in games in an effective way. Is there any combination of learning objectives and game elements that is particularly effective or challenging? Also, most of the existing research is not about games in the area of ICT. So, future research is needed to refine the guidelines for the specific area of concern.

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B Interview Guides

B.1 Interview Guide - Gender Expert

Introduction:

- Could you tell us a little bit about yourself?
- Can you describe your work related to gender and technology/ICT ?

Gender:

1. What are the benefits and challenges connected to gender equality in ICT?
2. What are the benefits and risks connected to creating a gender-specific design?
3. What do you think is important to take into consideration when creating an artifact designed for gender equality in ICT?

Games & Gender:

1. What are your thoughts on using a game to address the gender issue in ICT?
2. Can creating a game specifically for girls have a negative effect ? How?
3. Do you think the design, for instance colors and graphics, can have an impact on how effective the game will be? How?
4. How can we ensure that our game is not strengthening inequalities and contributes to gender discrimination?
5. We know you teach the module gender/race bias in machine learning, do you have any interesting examples of bias in technology we see in everyday life that can be relevant to include in our game?
6. Are there any topics related to gender and ICT you think would be relevant to include in a minigame?

Our Game: Game goals and guidelines

Goals: *Boost knowledge, fight stereotypes, promote self-confidence and provide role models*

1. Among the four goals that the game could fulfil, which do you think is the most important to include in order to work towards gender equality in ict? Why?
2. Among the four goal areas, which do you think is the least important to proceed with?
3. Are there any of the four goals you think would be a good combination?
4. Are there any of the four goals you think would be difficult to combine?
5. Which of the four goals do you think are most challenging to achieve?
6. Other than the four goals proposed, do you think of another goal that is suitable and should be included?

Game design guidelines are sent on beforehand. Make it clear that if she feels the guidelines are outside her field of expertise, it is okay to answer briefly.

1. Are there any guidelines you think we should be careful moving further with ?
2. Are there any guidelines you think are more relevant?
3. Are there any guidelines you think are less relevant?

B.2 Interview Guide - Game Expert

Interview question - Game Expert

Introduction

- Tell us about yourself
- Your work with games and if applicable, gender

Game Content and Minigames:

- Minigames:
    - Engagement in minigames, how can one maintain?
    - How do you think we can secure a common thread throughout the game?
    - We wish to create a game which only should be played once. How long (either playtime or number of minigames) do you think the game should be in order to optimize the attention, engagement, motivation and learning outcome?
- *Game Elements*
    - Which game elements are motivational and increase engagement in minigames?
- *Game Concepts (minigame templates)*
    - Do you think there is a maximum number of game concepts to be included in each game module? OR a maximum number of minigames in total in the serious game?

Game Design:

- Are there any differences of game design choices when designing a game for girls vs boys, if so which?
    - What should be included?
    - What should be avoided?
- What is your first-impression on the overall design of the game? Could it appeal to girls in secondary school?
- Do you have any suggestions for primary and secondary colors to use in the game that is gender neutral?

Learning Outcome:

- The presentation of information:
    - Which media form is most effective? How could it be presented to secure learning outcomes, but without making it boring?
        - Dialog, text, photos, videos?
- Do you think the learning goals are covered through the game?

Specific feedback for game:

- For each module:
    - Do any of the minigames not fit the module? If so, should it be dropped or moved to another module?
    - Would any of the minigames benefit from changing to another minigame template, if so – which?
    - Order of minigames in modules, right or should something be organized differently?
    - Do they support the learning object in the module? Enough games or more to do so?
    - Are there any pictures that should be improved or changed?
- Do you have any general feedback and improvements?
- Do you think the game can give an increased understanding of ICT and help close the gender gap?
- Are there any minigames that have too much or too little information before or after in order to secure learning outcomes for the player?

Introduction and end-modules:

- Which information do you think is necessary to include in the introduction in order to introduce the players to the field and ICT?
- Do you have any suggestions for games or information that could be included in the END-module? Possibly something that supports all four learning goals

Other / Low priority

- Do you have any suggestions for a name for the game?
- Do you think this game could appeal to boys as well?
    - If no, which elements ?

C Questionnaires

C.1 Pre-questionnaire

XploreIT - Før spill

Obligatoriske felter er merket med denne stjernen *

Prosjektbeskrivelse - Jenter i IT

Dette prosjektet er en masteroppgave på NTNU i Trondheim, ved fakultet for informasjonsteknologi og elektroteknikk, ved institutt for datateknologi og informatikk. Meningen med prosjektet er å finne ut om spill bestående av flere små spill og mikro-læring kan bidra med å øke jenters bevissthet og interesse for teknologi og IT, for å jobbe mot kjønnsgapet i IT-bransjen.

Denne spørreundersøkelsen vil kartlegge din interesse for IT før du spiller spillet. Deretter vil du spille spillet, etterfulgt av en ny spørreundersøkelse om spillet og din opplevelse av det.

Om deg

Fyll inn din spiller-ID/brukernavn *

Fyll inn det som står foran e-posten du har fått til å logge inn på spillet med.

For eksempel hvis e-posten er "bruker1@ntnu.no" så skal du **kun** skrive inn "bruker1"

Kjønn *

- ○ Jente
- ○ Gutt
- ○ Annen kjønnsidentitet
- ○ Ønsker ikke svare

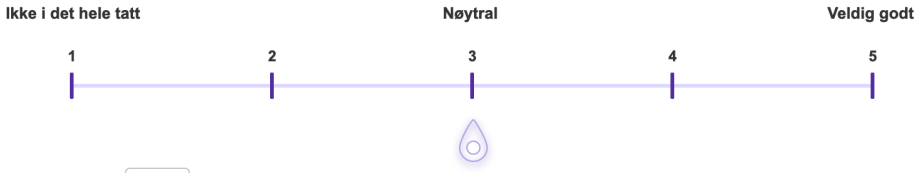
Alder *

Skriv inn din alder i feltet nedenfor. F.eks "15" om du er 15 år.

Om dine interesser

Liker du matte? *

1-5, der 1 er "Ikke i det hele tatt" og 5 er "Veldig godt"



Verdi

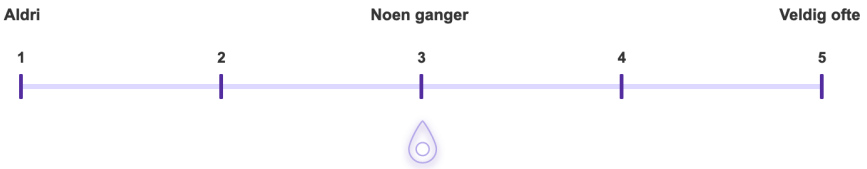
Har du erfaring med programmering? *

1-5, der 1 er "Ingen erfaring" og 5 er "Mye erfaring"

Verdi

Spiller du mye spill (mobilspill, videospill eller andre digitale spill) ? *

Eksempler: Playstation, Candy crush etc.



Verdi

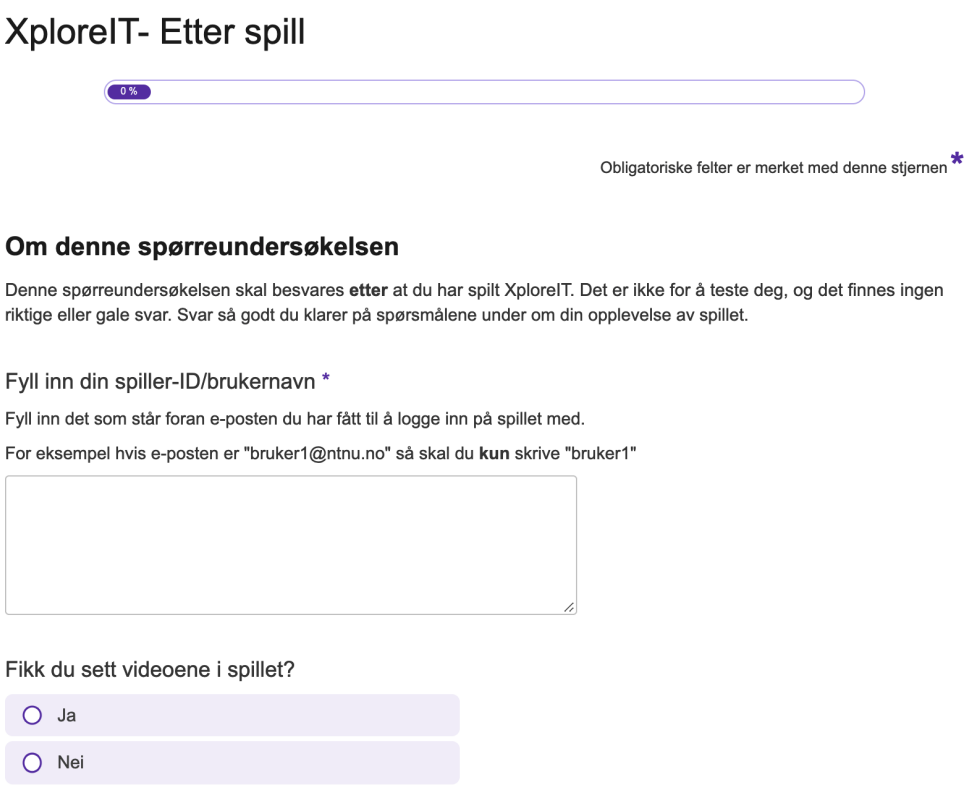
I hvilken grad er du enig i følgende utsagn?

Bevisst betyr "Å være klar over noe"

	Svært uenig	Uenig	Hverken enig eller uenig (Nøytral)	Enig	Svært enig
Jeg er bevisst på hva IT er *	○	○	○	○	○
Jeg er interessert i IT *	○	○	○	○	○
Jeg føler at IT og programmering kan gjøres av gutter og jenter *	○	○	○	○	○
Jeg kan se for meg å jobbe med teknologi	○	○	○	○	○

Send

C.2 Post-questionnaire



XploreIT- Etter spill

0 %

Obligatoriske felter er merket med denne stjernen *

Om denne spørreundersøkelsen

Denne spørreundersøkelsen skal besvares **etter** at du har spilt XploreIT. Det er ikke for å teste deg, og det finnes ingen riktige eller gale svar. Svar så godt du klarer på spørsmålene under om din opplevelse av spillet.

Fyll inn din spiller-ID/brukernavn *

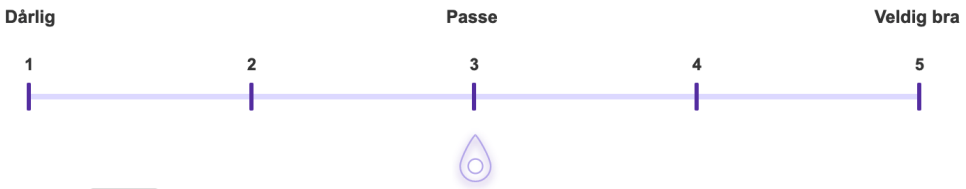
Fyll inn det som står foran e-posten du har fått til å logge inn på spillet med.

For eksempel hvis e-posten er "bruker1@ntnu.no" så skal du **kun** skrive "bruker1"

Fikk du sett videoene i spillet?

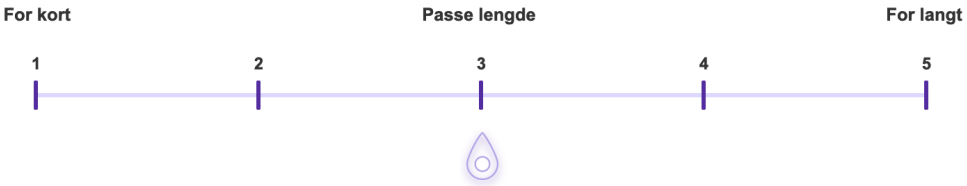
- Ja
- Nei

Hva er ditt helhetsinntrykk av spillet ? *



Verdi

Hva synes du om lengden på spillet ? *



Verdi

Neste side

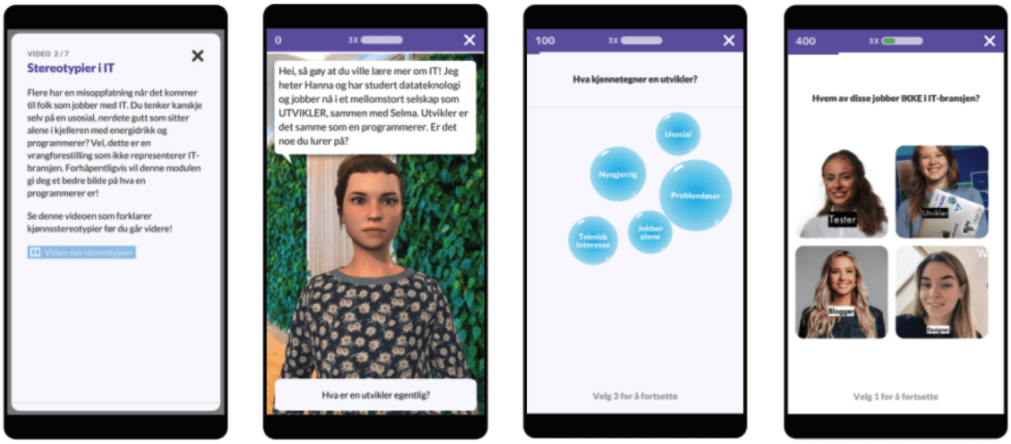
Om modulene

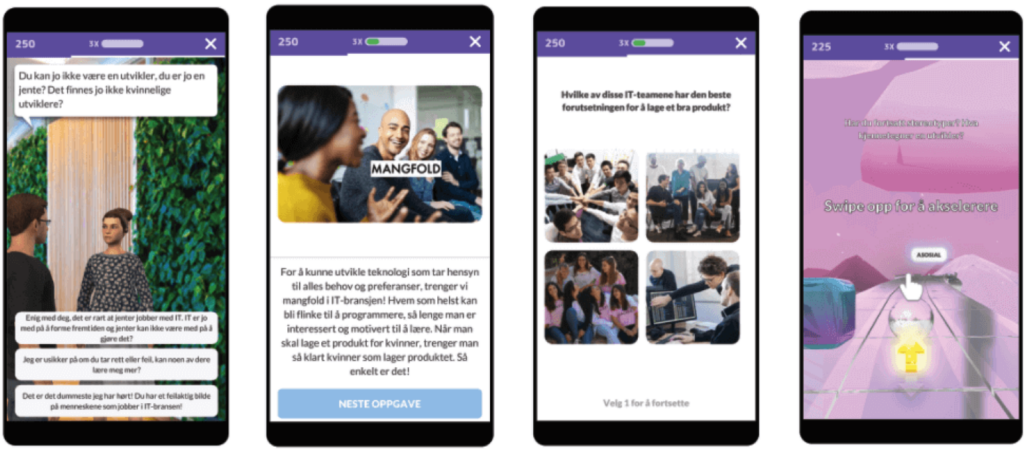
I spillet var det 6 **moduler:**

1. Introduksjon
2. Stereotypier
3. Få selvtillit
4. Rollemodeller
5. Kunnskapsboost
6. Avslutning

I de neste spørsmålene skal du huske tilbake modul 2,3,4 og 5. Dersom du ikke fikk spilt alle modulene kan du svare "Ikke relevant" ved dette spørsmålet.

2. Stereotypier

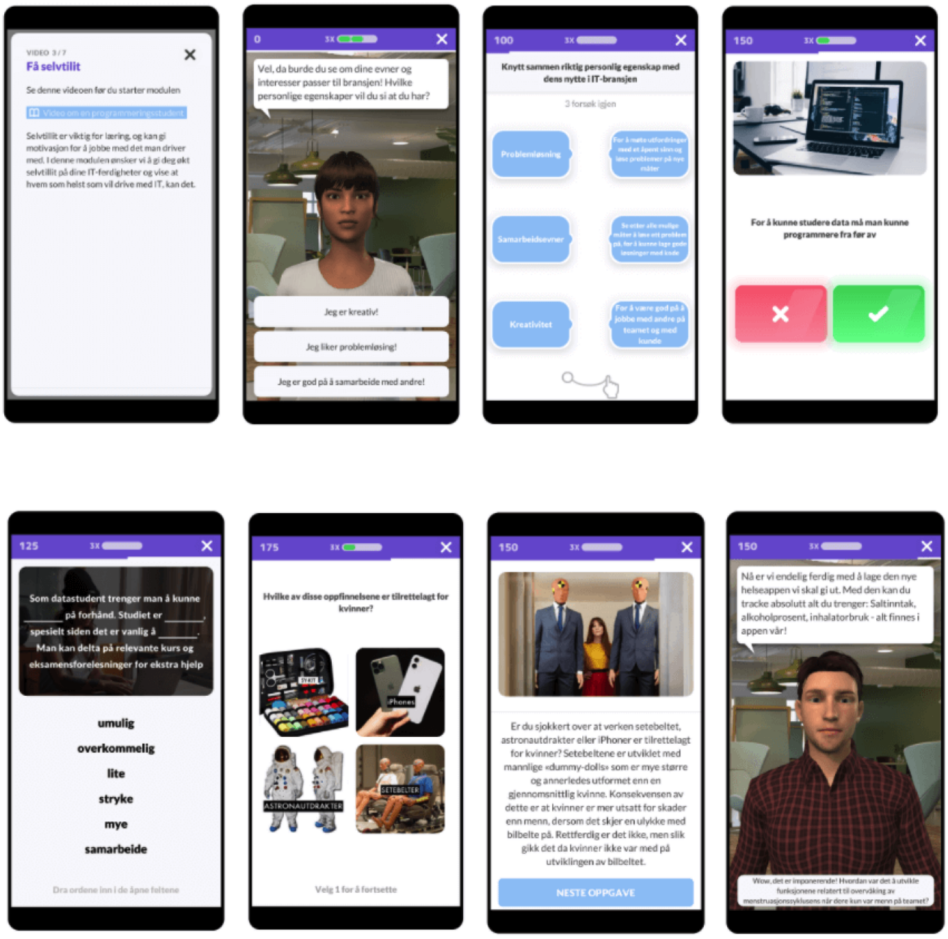




I hvilken grad er du enig i følgende utsagn?

	Svært uenig	Uenig	Hverken uenig eller enig (Nøytral)	Enig	Svært enig	Ikke relevant
Jeg synes denne modulen var vanskelig *	○	○	○	○	○	○
Innholdet i denne modulen var kjent for meg fra før *	○	○	○	○	○	○
Jeg synes denne modulen var underholdende *	○	○	○	○	○	○
Jeg føler at denne modulen ga meg bevissthet om IT *	○	○	○	○	○	○
Jeg har blitt mer interessert i IT etter å ha spilt denne modulen *	○	○	○	○	○	○

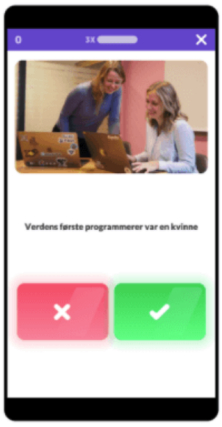
3. Selvtillit



I hvilken grad er du enig i følgende utsagn?

	Svært uenig	Uenig	Hverken uenig eller enig (Nøytral)	Enig	Svært enig	Ikke relevant
Jeg synes denne modulen var vanskelig *	○	○	○	○	○	○
Innholdet i denne modulen var kjent for meg fra før *	○	○	○	○	○	○
Jeg synes denne modulen var underholdende *	○	○	○	○	○	○
Jeg føler at denne modulen ga meg bevissthet om IT *	○	○	○	○	○	○
Jeg har blitt mer interessert i IT etter å ha spilt denne modulen *	○	○	○	○	○	○

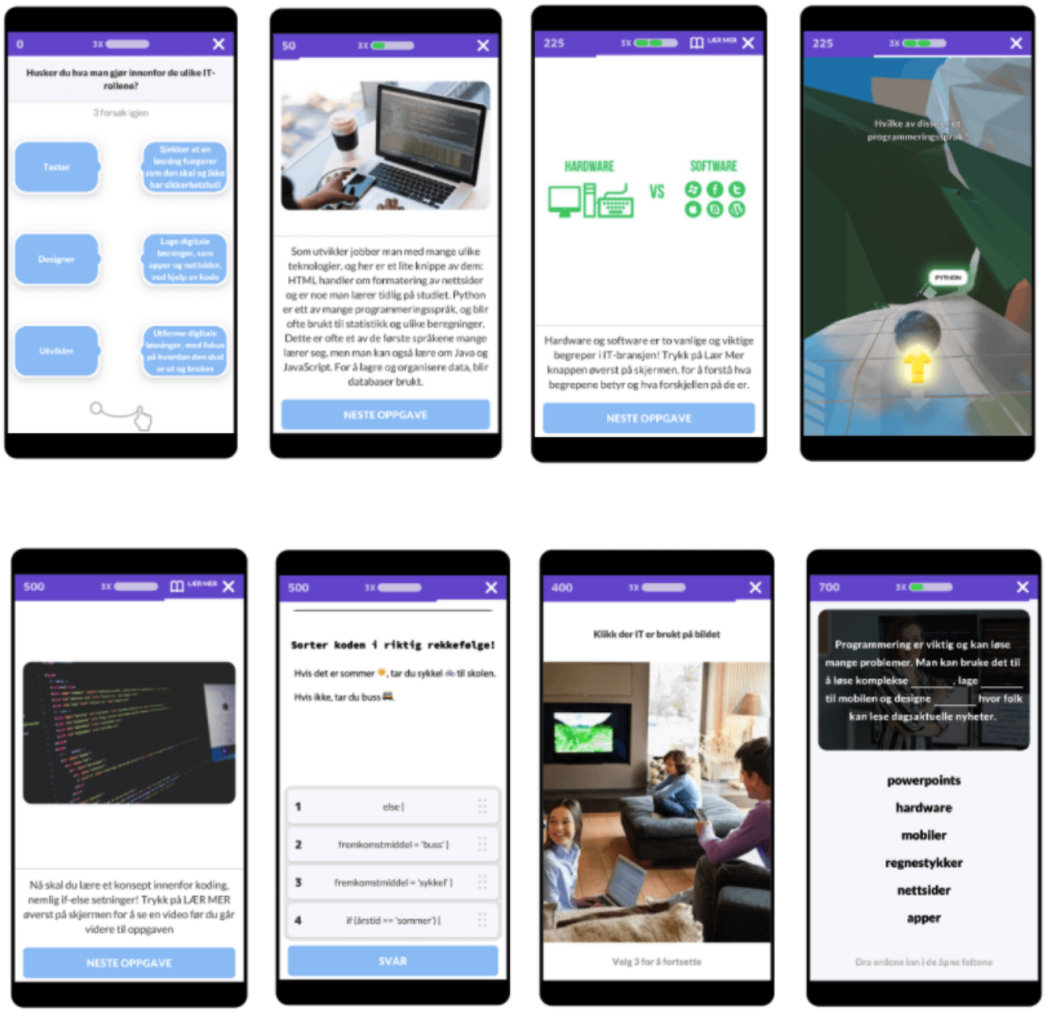
4. Rollemodeller



I hvilken grad er du enig i følgende utsagn?

	Svært uenig	Uenig	Hverken uenig eller enig (Nøytral)	Enig	Svært enig	Ikke relevant
Jeg synes denne modulen var vanskelig *	○	○	○	○	○	○
Innholdet i denne modulen var kjent for meg fra før *	○	○	○	○	○	○
Jeg synes denne modulen var underholdende *	○	○	○	○	○	○
Jeg føler at denne modulen ga meg bevissthet om IT *	○	○	○	○	○	○
Jeg har blitt mer interessert i IT etter å ha spilt denne modulen *	○	○	○	○	○	○

5. Kunnskapsboost



I hvilken grad er du enig i følgende utsagn?

	Svært uenig	**Uenig**	Hverken uenig eller enig (Nøytral)	Enig	Svært enig	Ikke relevant
Jeg synes denne modulen var vanskelig *	○	○	○	○	○	○
Innholdet i denne modulen var kjent for meg fra før *	○	○	○	○	○	○
Jeg synes denne modulen var underholdende *	○	○	○	○	○	○
Jeg føler at denne modulen ga meg bevissthet om IT *	○	○	○	○	○	○
Jeg har blitt mer interessert i IT etter å ha spilt denne modulen *	○	○	○	○	○	○

Læringsutbytte

I hvilken grad er du enig i utsagnene?

	Svært uenig	Uenig	Hverken enig eller uenig (Nøytral)	Enig	Svært enig
Jeg synes det var nok informasjon til at jeg kunne forstå oppgavene *	○	○	○	○	○
Jeg synes det var nok forklaringer av løsninger slik at jeg kunne gå videre uten å være forvirret *	○	○	○	○	○
Jeg har lært noe om IT ved å spille spillet *	○	○	○	○	○
Jeg har lært noe programmering ved å spille spillet *	○	○	○	○	○

Om din oppfatning av IT

I hvilken grad er du enig i følgende utsagn?

Bevisst betyr "Å være klar over noe"

	Svært uenig	Uenig	Hverken enig eller uenig (Nøytral)	Enig	Svært enig
Jeg er bevisst på hva IT er etter å ha spilt spillet *	○	○	○	○	○
Jeg er interessert i IT etter å ha spilt spillet *	○	○	○	○	○
Jeg føler at IT og programmering kan gjøres av gutter og jenter etter å ha spilt spillet *	○	○	○	○	○
Jeg kan se for meg å jobbe med teknologi etter å ha spilt spillet *	○	○	○	○	○
Jeg vil utforske IT videre etter å ha spilt dette spillet *	○	○	○	○	○

Er det noe mer du vil legge til om spillet?

Forrige side

Send

D Consent Forms

D.1 Gender Expert Interview

Vil du delta i forskningsprosjektet

”Bruken av spill som virkemiddel for å øke jenters bevissthet om og interesse for IT-studier”?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å lage et spill til tenåringsjenter for å øke bevissthet om og interesse for IT-studier. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg. Behandlingsansvarlig institusjon for prosjektet er NTNU.

Formål
Formålet med prosjektet er å forske på tekniske løsninger som kan jobbe mot kjønnsforskjellene som eksisterer innenfor IT-bransjen i dag. Det er mange faktorer som legger til grunn for dette problemet, blant annet kjønnsstereotypier, jenters mangel på kunnskap og selvtillit om IT og få kvinnelige rollemodeller innenfor IT. Spill viser seg å være et lovende verktøy for å øke jenters bevissthet om og interesse for IT-studier. Dette prosjektet vil derfor bestå av utvikling og evaluering av et spill for å få økt interesse og bevissthet om IT-studier blant tenåringsjenter.

Prosjektet er gjennomført i sammenheng med masteroppgaven til Ingrid Kindem og Cathrine Akre-Aas. Masterprosjektet gjennomføres under institutt for datateknologi og informatikk ved NTNU. Oppgaven startet i januar 2021 og vil bli avsluttet i juni 2021. Opplysningene skal ikke brukes til andre formål enn denne masteroppgaven.

Hvem er ansvarlig for forskningsprosjektet?
Institutt for datateknologi og informatikk ved Norges teknisk-naturvitenskapelige universitet (NTNU) er ansvarlig for prosjektet.

Hvorfor får du spørsmål om å delta?
Du får spørsmål om å delta på grunn av din kompetanse innen kjønnsstudier. Vi ønsker å intervjue en ekspert på kjønnsstudier, for å få nødvendig innsikt i kjønnsforskjeller som angår vår problemstilling og vårt arbeid. Ditt navn dukket opp etter å ha hørt foredraget ditt på arrangementet “BIAS - fordommer du ikke visste du hadde” i samarbeid med Kvinneprosjektet og Spark NTNU. Kontaktinformasjonen din er hentet fra NTNU sine nettsider.

Hva innebærer det for deg å delta?
Hvis du velger å delta i prosjektet, innebærer det at du deltar på et digitalt, semi-strukturert intervju. Det vil ta deg ca. 45 minutter og vil skje via Zoom. Intervjuet vil omhandle: Utfordringer knyttet til design for likestilling, kjønnspreferanser og -design i spill, i tillegg til en evaluering av retningslinjer for spilldesign knyttet til jenter og IKT. Dine svar i intervjuet vil bli lagret gjennom lydopptak og notater.

Det er frivillig å delta
Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykket tilbake uten å oppgi noen grunn. Alle dine personopplysninger vil da bli slettet. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger
Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket. Prosjektgruppen vil ha tilgang til lydopptakene. Lydopptak vil bli gjort ved hjelp av innebygd opptaksfunksjon på Zoom. Alle lydopptak vil bli transkribert og anonymisert, og hver deltaker vil bli tilegnet en unik brukerkode som vil hjelpe prosjektgruppen å anonymisere informasjonen slik at identifikasjon av deltakerne ikke vil være mulig. Dataene vil bli lagret på en passordbeskyttet server på NTNU.

Veileder av prosjektet vil ha tilgang til deler av den anonymiserte dataen. All data vil bli bevart anonymt og trygt hvor vi kun lagrer brukerkoden.

Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?
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.

Dine rettigheter
Så lenge du kan identifiseres i datamaterialet, har du rett til:
- innsyn i hvilke personopplysninger som er registrert om deg, og å få utlevert en kopi av opplysningene,
- å få rettet personopplysninger om deg,
- å få slettet personopplysninger om deg, og
- å sende klage til Datatilsynet om behandlingen av dine personopplysninger.

Hva gir oss rett til å behandle personopplysninger om deg?
Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra NTNU har NSD – Norsk senter for forskningsdata AS vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Hvor kan jeg finne ut mer?
Hvis du har spørsmål til studien, eller ønsker å benytte deg av dine rettigheter, ta kontakt med:
- Institutt for datateknologi og informatikk på NTNU ved prosjektansvarlig Monica Divitini.
- Vårt personvernombud: Thomas Helgesen, 93079038, thomas.helgesen@ntnu.no

Hvis du har spørsmål knyttet til NSD sin vurdering av prosjektet, kan du ta kontakt med:
- NSD – Norsk senter for forskningsdata AS på e-post (personverntjenester@nsd.no) eller på telefon: 55 58 21 17.

Med vennlig hilsen

Monica Divitini *Ingrid Kindem og Cathrine Akre-Aas*

(Forsker/veileder)

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet ”Bruken av spill som virkemiddel for å øke jenters bevissthet om og interesse for IT-studier”, og har fått anledning til å stille spørsmål. Jeg samtykker til:

- □ å delta i intervju

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet

---

(Signert av prosjektdeltaker, dato)

D.2 Co-design Workshop

Vil du delta i forskningsprosjektet

”Bruken av spill som virkemiddel for å øke jenters bevissthet om og interesse for IT-studier”?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å lage et spill til tenåringsjenter for å øke bevissthet om og interesse for IT-studier. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg. Behandlingsansvarlig institusjon for prosjektet er NTNU.

Formål
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Prosjektet er gjennomført i sammenheng med masteroppgaven til Ingrid Kindem og Cathrine Akre-Aas. Masterprosjektet gjennomføres under institutt for datateknologi og informatikk ved NTNU. Oppgaven startet i januar 2021 og vil bli avsluttet i juni 2021. Opplysningene skal ikke brukes til andre formål enn denne masteroppgaven.

Hvem er ansvarlig for forskningsprosjektet?
Institutt for datateknologi og informatikk ved Norges teknisk-naturvitenskapelige universitet (NTNU) er ansvarlig for prosjektet.

Hvorfor får du spørsmål om å delta?
Du får spørsmål om å delta på grunn av at du er en jente på et teknologistudie. Vi mener dette gir deg en forståelse for problemstillingen vi undersøker, i tillegg til innsikt gjennom erfaringer du selv har hatt som tidligere ungdomsskoleelev. Ditt navn dukket opp basert på at du går på et studie ved IDI, NTNU. Kontaktinformasjonen din er hentet via eget nettverk.

Hva innebærer det for deg å delta?
Hvis du velger å delta i prosjektet, innebærer det at du deltar på en digital, kollaborativ design workshop. Det vil ta deg ca. 90 minutter. Workshopen vil være kreativ og omhandle design av oppgaver til et spill, som gjøres ved å kombinere ulike forhåndsspesifiserte elementer til minispill-konsepter. Det kreves ingen teknisk erfaring eller kunnskap for å delta i workshopen. Under workshopen vil det bli tatt lydopptak og notater, i tillegg til at resultater fra det digitale whiteboardet vil bli lagret.

Det er frivillig å delta
Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykket tilbake uten å oppgi noen grunn. Alle dine personopplysninger vil da bli slettet. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

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Veileder av prosjektet vil ha tilgang til deler av den anonymiserte dataen. All data vil bli bevart anonymt og trygt hvor vi kun lagrer brukerkoden.

Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?
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- Institutt for datateknologi og informatikk på NTNU ved prosjektansvarlig Monica Divitini.
- Vårt personvernombud: Thomas Helgesen, 93079038, thomas.helgesen@ntnu.no

Hvis du har spørsmål knyttet til NSD sin vurdering av prosjektet, kan du ta kontakt med:
- NSD – Norsk senter for forskningsdata AS på e-post (personverntjenester@nsd.no) eller på telefon: 55 58 21 17.

Med vennlig hilsen

Monica Divitini *Ingrid Kindem og Cathrine Akre-Aas*

(Forsker/veileder)

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet ”Bruken av spill som virkemiddel for å øke jenters bevissthet om og interesse for IT-studier”, og har fått anledning til å stille spørsmål. Jeg samtykker til:

- □ å delta på digital workshop

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet

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(Signert av prosjektdeltaker, dato)

D.3 Game Expert Interview

Vil du delta i forskningsprosjektet

”Bruken av spill som virkemiddel for å øke jenters bevissthet om og interesse for IT-studier”?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å lage et spill til tenåringsjenter for å øke bevissthet om og interesse for IT-studier. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg. Behandlingsansvarlig institusjon for prosjektet er NTNU.

Formål
Formålet med prosjektet er å forske på tekniske løsninger som kan jobbe mot kjønnsforskjellene som eksisterer innenfor IT-bransjen i dag. Det er mange faktorer som legger til grunn for dette problemet, blant annet kjønnsstereotypier, jenters mangel på kunnskap og selvtillit om IT og få kvinnelige rollemodeller innenfor IT. Spill viser seg å være et lovende verktøy for å øke jenters bevissthet om og interesse for IT-studier. Dette prosjektet vil derfor bestå av utvikling og evaluering av et spill for å få økt interesse og bevissthet om IT-studier blant tenåringsjenter.

Prosjektet er gjennomført i sammenheng med masteroppgaven til Ingrid Kindem og Cathrine Akre-Aas. Masterprosjektet gjennomføres under institutt for datateknologi og informatikk ved NTNU. Oppgaven startet i januar 2021 og vil bli avsluttet i juni 2021. Opplysningene skal ikke brukes til andre formål enn denne masteroppgaven.

Hvem er ansvarlig for forskningsprosjektet?
Institutt for datateknologi og informatikk ved Norges teknisk-naturvitenskapelige universitet (NTNU) er ansvarlig for prosjektet.

Hvorfor får du spørsmål om å delta?
Du får spørsmål om å delta på grunn av din kompetanse innenfor spill. Vi ønsker nødvendig innsikt om spill, spillelementer og design som angår vår problemstilling og vårt arbeid. Ditt navn dukket opp via vår veileder, Monica Divitini, og du har blitt kontaktet av henne.

Hva innebærer det for deg å delta?
Hvis du velger å delta i prosjektet, innebærer det at du deltar på et digitalt, semi-strukturert intervju. Det vil ta deg ca. 45 minutter og vil skje via Zoom. Intervjuet vil omhandle: Spilldesign, kjønnspreferanser i og læringsutbytte fra spill, i tillegg til konkrete spørsmål knyttet til en prototype av et spill. Det vil bli tatt lydopptak av intervjuet for å forenkle noteringsprosessen til prosjektgruppen.

Det er frivillig å delta
Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykket tilbake uten å oppgi noen grunn. Alle dine personopplysninger vil da bli slettet. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger
Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket. Prosjektgruppen vil ha tilgang til lydopptakene. Lydopptak vil bli gjort ved hjelp av innebygd opptaksfunksjon på Zoom. Alle lydopptak vil bli transkribert og anonymisert, og hver deltaker vil bli tilegnet en unik brukerkode som vil hjelpe prosjektgruppen å anonymisere informasjonen slik at identifikasjon av deltakerne ikke vil være mulig. Dataene vil bli lagret på en passordbeskyttet server på NTNU.

Veileder av prosjektet vil ha tilgang til deler av den anonymiserte dataen. All data vil bli bevart anonymt og trygt hvor vi kun lagrer brukerkoden.

Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?
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.

Dine rettigheter
Så lenge du kan identifiseres i datamaterialet, har du rett til:
- innsyn i hvilke personopplysninger som er registrert om deg, og å få utlevert en kopi av opplysningene,
- å få rettet personopplysninger om deg,
- å få slettet personopplysninger om deg, og
- å sende klage til Datatilsynet om behandlingen av dine personopplysninger.

Hva gir oss rett til å behandle personopplysninger om deg?
Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra NTNU har NSD – Norsk senter for forskningsdata AS vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Hvor kan jeg finne ut mer?
Hvis du har spørsmål til studien, eller ønsker å benytte deg av dine rettigheter, ta kontakt med:
- Institutt for datateknologi og informatikk på NTNU ved prosjektansvarlig Monica Divitini.
- Vårt personvernombud: Thomas Helgesen, 93079038, thomas.helgesen@ntnu.no

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Med vennlig hilsen

Monica Divitini *Ingrid Kindem og Cathrine Akre-Aas*

(Forsker/veileder)

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet ”Bruken av spill som virkemiddel for å øke jenters bevissthet om og interesse for IT-studier”, og har fått anledning til å stille spørsmål. Jeg samtykker til:

- □ å delta i intervju

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet

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(Signert av prosjektdeltaker, dato)

D.4 Testing with Target Group

Vil du delta i forskningsprosjektet

”Bruken av spill som virkemiddel for å øke jenters bevissthet om og interesse for IT-studier”?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å lage et spill til tenåringsjenter for å øke bevissthet om og interesse for IT-studier. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg. Behandlingsansvarlig institusjon for prosjektet er NTNU.

Formål
Formålet med prosjektet er å forske på tekniske løsninger som kan jobbe mot kjønnsforskjellene som eksisterer innenfor IT-bransjen i dag. Det er mange faktorer som legger til grunn for dette problemet, blant annet kjønnsstereotypier, jenters mangel på kunnskap og selvtillit om IT og få kvinnelige rollemodeller innenfor IT. Spill viser seg å være et lovende verktøy for å øke jenters bevissthet om og interesse for IT-studier. Dette prosjektet vil derfor bestå av utvikling og evaluering av et spill for å få økt interesse og bevissthet om IT-studier blant tenåringsjenter.

Prosjektet er gjennomført i sammenheng med masteroppgaven til Ingrid Kindem og Cathrine Akre-Aas. Masterprosjektet gjennomføres under institutt for datateknologi og informatikk ved NTNU. Oppgaven startet i januar 2021 og vil bli avsluttet i juni 2021. Opplysningene skal ikke brukes til andre formål enn denne masteroppgaven.

Hvem er ansvarlig for forskningsprosjektet?
Institutt for datateknologi og informatikk ved Norges teknisk-naturvitenskapelige universitet (NTNU) er ansvarlig for prosjektet.

Hvorfor får du spørsmål om å delta?
Du får spørsmål om å delta på grunn av at du er i alderen 12-18 år, og inngår i vår målgruppe for dette forskningsprosjektet.

Hva innebærer det for deg å delta?
Hvis du velger å delta i prosjektet, innebærer det at du deltar på en digital aktivitet, der du skal spille et spill, svare på en kort spørreundersøkelse og en kort samtale om din opplevelse av aktiviteten. Det vil ta deg 60-90 minutter. Du kan delta alene eller i en gruppe. Det kreves ingen teknisk erfaring eller kunnskap for å delta. Det kreves tilgang til egen PC og internett mens du deltar i aktiviteten. Det er også en fordel om du har tilgang til hodetelefoner, da spillet inneholder video og lyder. Under aktiviteten vil det bli tatt lydopptak og notater, i tillegg til at resultater fra det spillet vil bli lagret.

Det er frivillig å delta
Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykket tilbake uten å oppgi noen grunn. Alle dine personopplysninger vil da bli slettet. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger
Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket. Prosjektgruppen vil ha tilgang til lydopptaket, notatene og resultatet fra aktiviteten. Disse vil bli transkribert og anonymisert, og hver deltaker vil bli tilegnet en unik brukerkode som vil hjelpe prosjektgruppen å anonymisere informasjonen slik at identifikasjon av deltakerne ikke vil være mulig. Dataene vil bli lagret på en passordbeskyttet server på NTNU. Skjermbilder av resultater fra spillet kan bli publisert i masteroppgaven, men kan ikke knyttes til den enkelte spillers resultater.

Veileder av prosjektet vil ha tilgang til deler av den anonymiserte dataen. All data vil bli bevart anonymt og trygt hvor vi kun lagrer brukerkoden.

Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?
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, i juni 2021.

Dine rettigheter
Så lenge du kan identifiseres i datamaterialet, har du rett til:
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- å få rettet personopplysninger om deg,
- å få slettet personopplysninger om deg, og
- å sende klage til Datatilsynet om behandlingen av dine personopplysninger.

Hva gir oss rett til å behandle personopplysninger om deg?
Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra NTNU har NSD – Norsk senter for forskningsdata AS vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Hvor kan jeg finne ut mer?
Hvis du har spørsmål til studien, eller ønsker å benytte deg av dine rettigheter, ta kontakt med:
- Masterstudentene, Ingrid Kindem (48264615, iakindem@gmail.com) og Cathrine Akre-Aas (90562036, cathrineakreaas@gmail.com)
- Institutt for datateknologi og informatikk på NTNU ved prosjektansvarlig Monica Divitini.
- Vårt personvernombud: Thomas Helgesen, 93079038, thomas.helgesen@ntnu.no

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Med vennlig hilsen

Monica Divitini *Ingrid Kindem og Cathrine Akre-Aas*

(Forsker/veileder)

Samtykkeerklæring for deltakere som er 16 år eller eldre

Jeg har mottatt og forstått informasjon om prosjektet "Bruken av spill som virkemiddel for å øke jenters bevissthet om og interesse for IT-studier", og har fått anledning til å stille spørsmål. Jeg samtykker til:

- □ å delta på digital spill-aktivitet, inkludert spørreundersøkelse og kort samtale.

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet.

Dersom du gjennomfører spillaktiviteten på fritiden, ber vi deg sende samtykkeerklæringen på e-post til en av masterstudentene (iakindem@gmail.com eller cathrineakreaas@gmail.com), så tar vi kontakt med deg for å avtale tid for gjennomføring av spillaktiviteten.

Navn på deltaker (Blokkbokstaver): E-post til deltaker (Blokkbokstaver):

(Signert av prosjektdeltaker, dato)

Samtykkeerklæring deltaker under 16 år

Jeg har mottatt og forstått informasjon om prosjektet "Bruken av spill som virkemiddel for å øke jenters bevissthet om og interesse for IT-studier", og har fått anledning til å stille spørsmål. Jeg samtykker til:

- □ at mitt barn/vergehaver kan delta på digital spill-aktivitet inkludert spørreundersøkelse og intervju.

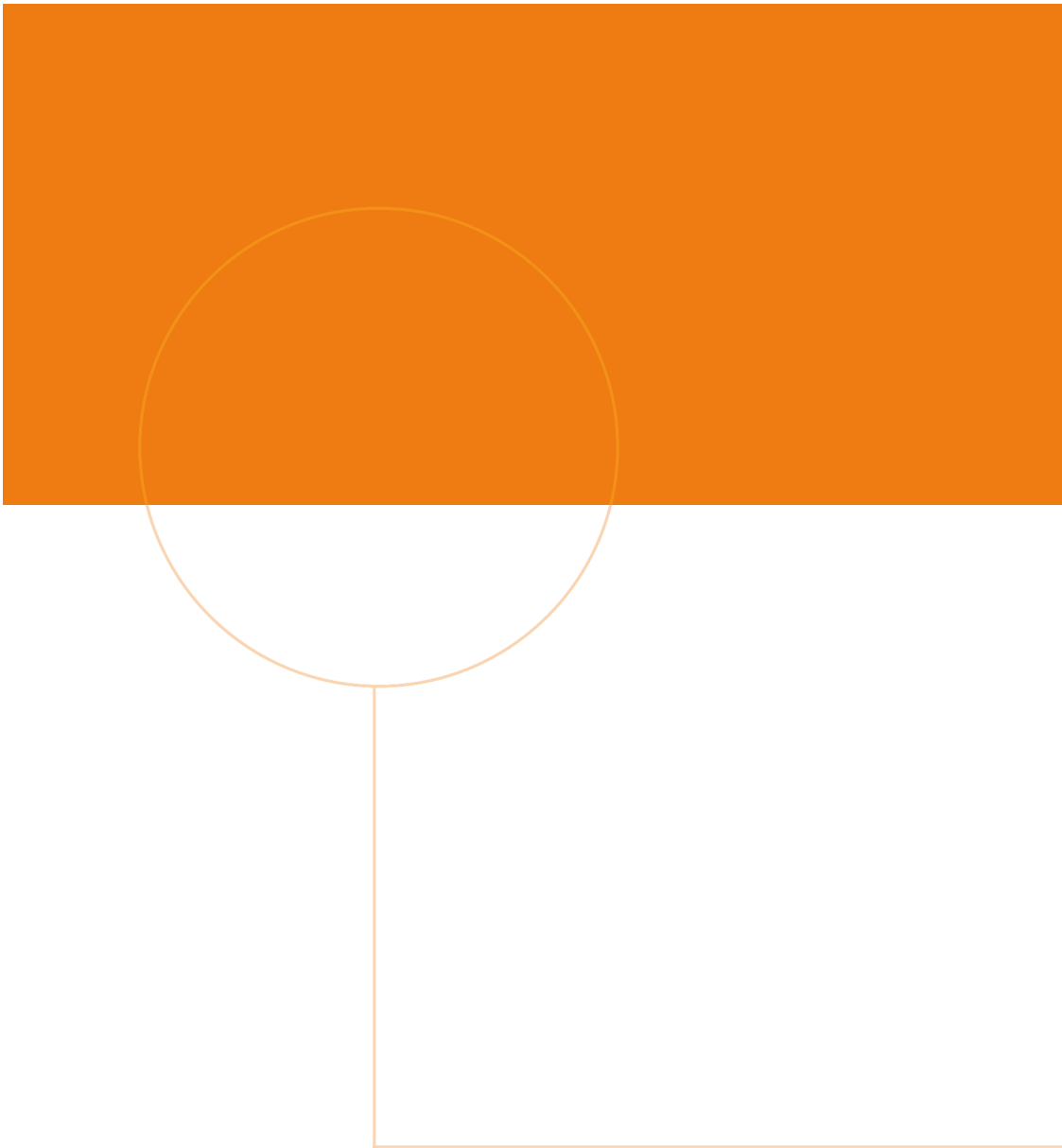
Jeg samtykker til at deltakerens opplysninger behandles frem til prosjektet er avsluttet.

Dersom du gjennomfører spillaktiviteten på fritiden, ber vi deg sende samtykkeerklæringen på e-post til en av masterstudentene (iakindem@gmail.com eller cathrineakreaas@gmail.com), så tar vi kontakt med deg for å avtale tid for gjennomføring av spillaktiviteten.

Navn på deltaker (Blokkbokstaver):

E-post til foresatt (Blokkbokstaver):

(Signert av forelder/verge, dato)



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