CHALMERS
UNIVERSITY OF TECHNOLOGY
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QUIZGO

Incorporating physical activities in middle school education

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Cover: Three screens of the final prototype for QUIZGO.

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Abstract

This master's thesis presents the process of formulating a set of criteria that should be considered when making an educational and engaging user experience for students while doing physical activity at middle school. The stakeholder of the project was *Semcon* and the overall goal of the project was to design the user interface and develop the gamification aspect of a quiz application that enable students to learn while moving outdoors. To formulate the criteria previous research and research through design were utilized. The result is a list of eleven criteria and a high fidelity prototype that explores these. However, there are probably more criteria that can be considered and they need further testing to be validated.

Keywords: User experience, game design, educational, health, mobile application, physical activity, quiz.

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Amanda Jonsson, Emilia Vestlund, Gothenburg, June 2020

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1

Introduction

There is a clear connection between physical activity and health [1]. Physical inactivity among young people has been a huge concern due to its increased risks of getting diseases such as type 2 diabetes and obesity. On the contrary, physical activity has shown great benefits on health, such as increased mental health and musculoskeletal health. Additionally, research has shown that there is a connection between physical activity and school performance [1]. It has been discovered that health factors have both direct and indirect impacts on educational outcomes and students with good health learn better [2][3]. To increase student engagement and decrease the achievement gap, schools need to establish an environment where students are both engaged and have good health. As a part of a research project for Equal health run by Malmö University, *Semcon* has started a project which will develop a mobile application that can enable students to learn while moving outdoors.

One of the sustainable development goals from the United Nations General Assembly is *good health and well-being* [4]. The public health of a nation is not just the degree of health but also the distribution of health between people according to the Swedish National Sports Association [5]. The background to the initiative for Equal health was the need to develop new methods to counteract the fact that health is getting more unequal in the population [6]. This problem is referred to as The Health Gap and implies that the gap increases between the part of the population that has good health and the part that has poor health. Equal health has partners from commercial and industrial life, public sector and citizens from the area called Lindängen in Malmö.

Semcon worked on the Equal health project during 2018 and 2019. First, user research was carried out. Interviews were performed with the different labs in Equal Health in Malmö. During the interviews, the User Experience department at *Semcon* got a better understanding of the needs and challenges of the diverse target groups involved in the different labs. The work continued with idea generation workshops with the purpose to create a couple of concepts. One of the concepts, **Treasures of Lindängen**, more explained in *Section 2.2*, was prototyped and developed as an Android application by the User Experience and the Software and Architecture departments at *Semcon*. This thesis will continue developing the application with a focus on developing the game aspect as well as the overall user experience.

1.1 Concept

The primary user groups of the concept are students at middle schools and their teachers. The concept is a quiz application where the users answer questions while walking. The quiz can be used on different topics, for example, natural science and languages. During the walk, the questions appear on the screen. The quiz creator, the teachers, decide a walking path and specify how long the path should be and how many questions that should appear throughout the path. The quiz can be either step or GPS based. Step based means that the quiz creator specifies how many steps the users should walk during the quiz and GPS based means that the quiz creator specifies a specific route where the question should appear on the screen. When the users choose a quiz, they must start walking to see the questions and answer them. When they have completed a quiz, they can choose another quiz. Teachers will be able to see the students' results and statistics.

1.2 Research question

Which criteria should be considered when making an educational and engaging quiz as a physical activity for students in middle school?

The overall goal of the project is to motivate the users to become more physically active and increase the health quality of the demography. Since the context of the application is education, the teachers' perspective also needs to be taken into consideration. The goal of the thesis work is to design the game and the user interface of the quiz application.

1.3 Aim

The aim of this master thesis is to continue the work on the quiz application. The research will be presented from scientific literature and user studies about the connection between physical activity and motivation and a review of different attempts of making education more engaging will be presented.

The task is to develop the gamification aspect of the concept. Additionally, the overall user experience will be further developed, as in user research, prototypes, and testing. A high fidelity prototype, in the form of a graphical user interface, will be designed as an attempt to find criteria that should be considered when making an educational and engaging quiz as a physical activity for students in middle school.

1.4 Stakeholders

Chalmers University of Technology - offers education in various areas such as technology, science, architecture and maritime engineering [7]. They also conduct research and their vision is a sustainable future. *Chalmers* is the recipient and liable

of this master thesis.

Semcon - a company that combines technology, usability and design in innovative ways, from creative concepts to product development and digital solutions [8]. It is a company that prioritizes human beings before technology. They have offices in eight countries and work with product development in science, energy, vehicles, industry and telecom. This thesis is being conducted as a part of a project at *Semcon*.

Amanda Jonsson and Emilia Vestlund - the performers of this master thesis project. Their goal is to contribute to research in the area of User Experience and Game Design and deliver a high-fidelity prototype as the result which will act as a proposition to a solution of the defined problem.

Students and teachers at middle schools - they are the primary user groups and it is therefore of great importance to know their opinions, attitudes and needs. Middle school students in Sweden, where the research takes place, are between 10 to 13 years old.

1.5 Scope

The scope of the project is to deliver a high fidelity prototype. Implementation of the application will not be part of the project. It has been discussed with *Semcon* that, in the future, the application could be used by other user groups as well, for example, for orientation or personal quizzes. However, these user groups will not be in the scope of this thesis. Another request is that the application, in the future, should be able to work on both smartphones and tablets. This will be taken into consideration but will not be in the scope of this thesis.

2
Background

This section will describe what research areas the research question belongs to. Additionally, this section will discuss related work such as quiz applications, games that encourage physical activity, quiz applications that encourage physical activity and digital tools for school assessment and communication. The application in this thesis is an attempt of combining all these aspects trying to make a quiz game that encourages students to be more physically active.

2.1 Research area

The research problem is to find criteria that should be considered when making an educational and engaging quiz as a physical activity for students in middle school. This research question is in the scope of several research areas where the main ones are user experience design and game design, which both are included in the broader field interaction design. Additionally, the research question is also in the scope of the research areas education and health. The research areas will be narrowed down and combined to fit the scope of the research.

2.1.1 Interaction design

The essence of interaction design is to design the interaction between a user and an interactive artifact to enhance and augment the way people communicate and work [9]. This could be, for example, mobile applications or interactive paintings. The goal is to make the interaction enjoyable, evoke engagement and reduce frustration and annoyance. In summation, the aim is to design interactive products that, from the users' perspective, are pleasurable to use, easy to understand and effective. Sharp et al. [9] suggest to study and compare well-designed products and poor-designed products to get an understanding of what it means for a product to be usable or not. The field of interaction design is very broad because the interaction between users and a product often includes aspects like aesthetics, sounds and motions [10].

To design good interaction between users and a product an understanding of how people interact and communicate with technology is needed and empathy with people has to be established.

2.1.1.1 User Experience Design

Digital interactive products must consider pragmatic aspects such as goal achievement as well as hedonic aspects, for instance, the need for stimulation, personal growth, evoking of memories and communication about self-identity social contexts [11][12]. User experience design in the process to provide products that evoke relevant and meaningful experiences to users [13]. User experience design is often used as if it would be interchangeable with terms as "usability" and "user interface design" and while those terms are important parts of the user experience design they are only subsets of it. User experience design includes the whole process of bringing in and integrating a product and aspects such as branding, designing and function. The work as a user experience designer begins long before the product is in the hands of the user.

2.1.1.2 Game Design

For hundreds of years, the field game design has not been considered a field but a culture. This changed after the explosion of computer games and now the game design has become a big deal [14]. The domain of game design is the aesthetics of interactive systems. Designing a game is about designing dynamic systems and space for players to inhabit. The focus for a game designer is therefore to design gameplay, rules and structure which will become experiences for players. Game design is different from user experience design because it is not just about minimizing the cognitive load of a user with an as simple user interface as possible. Game design should not just focus on usability but also playability [15]. Playability refers to how playable a game is and the overall quality of its gameplay. Playability for mobile games can be measured with playability heuristics [16].

2.1.2 Physical health in education

Both *quality education* and *good health and well-being* are in the system development goals made by the UN [4] hence is of great importance. Health is not just the absence of sickness and disabilities. It is also a state of complete physical, mental and social well-being according to the World Health Organization [17]. The public health of a nation is not just measuring the degree of health of everybody. Public health is also the distribution of health between people [5] and therefore health equality is of great importance.

Teachers are already trying to incorporate health in education in more subjects than physical education. An emeritus professor, Herb Broda, suggests that in the 21st century the schoolyard should be used as a teaching tool [18]. One example of using the schoolyard as a teaching tool is to explain the concept of parallel lines. First, the teacher teaches the definition of parallel lines in the classroom and then goes outside to show and find examples in nature. It is considered beneficial since it has a change of pace and place. Since the students go outside they also get more movement which will impact the health of the students. Another example is that teachers give the students different words. The students do not know their word

and have to walk around, outside or in the classroom, to other classmates which will explain the word. Then the students can both interact with other students by learning collaborative but also incorporate movement in learning.

2.2 Current status of the application

In this section, the previous work will be summarized including research and the current application.

2.2.1 Previous research

As mentioned in *Section 1* Semcon has worked on this application during 2018 and 2019. They held interviews with the different labs in Equal Health, which are mental health, social health, dental health and diet, safety in the environment, women's health and fitness justice. The interviews gave Semcon an insight into the different labs' work and what they found important and challenging. Based on these insights they had idea generation workshops where ideas and concepts were formed. The result of the workshops were several concepts, for example an outdoor gym application, a nature application and the quiz application in this thesis. The concept of the quiz application was further developed. The first prototype was being tested at three different schools; Brandströmska in Gothenburg, Fjordskolan in Onsala and Lindängen in Malmö. A total of fifteen students in the ages between 9-11 years and five teachers participated in the test session.

Some of the input from the students are listed below:

- It is fun to be outside
- Fun to have the homework in the mobile instead of in a book
- Good to receive feedback on the questions directly
- Would like different themes on the quizzes
- Would like to see exactly where to go
- Be able to choose the difficulty level
- Get a reminder each day to do a quiz
- Wants to be able to collect points
- Would like physical challenges along the way, for example, push-ups
- Would like more feedback like sounds and animations

Input from the teachers are listed below:

- Could be used in education and for homework
- Good that the students can see what answering alternative that is incorrect until they select the right alternative
- Share quiz with a code is good
- Good that the questions cover the whole screen because then it is easier to focus

- Would like the students to be notified when the next question is on the screen, to prevent them from looking at the screen during the whole walk
- Should show a progress bar
- Adding a quiz should be easy as in being able to change the order of the questions and adding and removing questions.

All of these findings were taken into consideration when the project was started.

2.2.2 The application

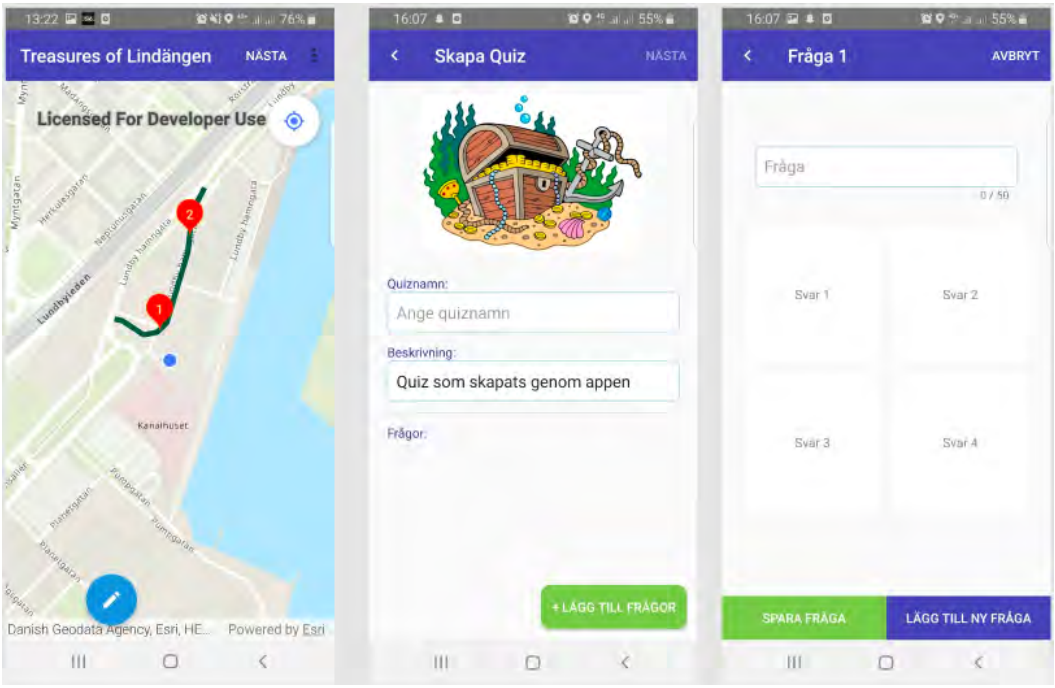

Figure 2.1: Three screens of the current application.

Semcon used the test result from the study and designed and developed an android application. Three screens from the developed application at its current status are shown in the *Figure 2.1*.

The current status of the application is that it is a location or step based quiz game where teachers can create quizzes. When making a quiz the teacher will enter name, description, questions and the route or number of steps of the quiz. The students can see quizzes on their main screen and choose which quiz to take. In order to get a question in the quiz, the students have to walk to the location of the question or walk the requested number of steps. The students can then answer the question from the given alternatives and then continue walking to the next question.

For further development *Semcon* has requested the statistics part for the teachers, more game elements, personal quiz library, sharing quizzes, better user experience, the overall story and how to join a quiz in an easy way.

2.3 Related work

The following section will describe areas and applications that have similarities with the concept of the application. The section will end with a conclusion of why these applications relate to the concept.

2.3.1 Quiz applications

A quiz is a game where players, either individually or in teams, answer questions, with the attempt to answer correctly [19]. Quizzes can have different themes and focus on diverse subjects but the purpose is to test the players' knowledge on a specific topic. The word quiz has had different meanings throughout history and it was not until the middle of the 19th century it got the meaning it has today. Quizzes can be used in education as a form of assessment. In this case, the questions are often easier and require less time to perform and the questions often have a less difficulty level. A quiz can be in the shape of a board game, online or as a mobile application. An example of a quiz game is Kahoot! which is a game-based learning platform that is used as a pedagogic technology in schools [20]. The learning games are multiple-choice quizzes that can be accessed in the Kahoot! app or via the web browser.

Kahoot! can be used in schools to determine students' knowledge, either as an innovative classroom activity or for formative assessment. The host can create a learning game or a quiz on any topic and in any language or choose from the quizzes available [21]. Kahoot! recommend that the users host the quiz on a big screen to engage students. Additionally, Kahoot! can be used by companies to gamify learning at the workplace and it can be used in users' homes to make friends and family play a quiz in an engaging and fun way.

Kahoot! has many similarities with the concept in this thesis. They can both be used to examine students' knowledge in a game-based learning platform. The great difference is that Kahoot! has no focus on physical activity and the users are not supposed to walk while doing the quiz.

2.3.2 Games that encourage physical activity

In today's society lifestyle has become highly sedentary [22]. Physical activities, such as sports and exercises, are being less present in daily life whereas sedentary activities such as watching TV and sitting by the computer are more frequently present. These sedentary activities are big parts of the contemporary lifestyle and it is difficult to change. This problem has been addressed and an approach to solve this is to combat it in the context of games. Several game technologies have been developed with the purpose to encourage physical activity, such as Dance-Dance Revolution and Wii. A game that got extensive attention during its release in 2016 is Pokémon GO. Pokémon GO is an application made by Niantic, Inc. [23]. The application is a location-based game and uses augmented reality for players to cap-

ture, play, locate and battle with pokémons. The pokémons are virtual creatures that appear on the screen as if they were in the real world together with the player. Since the game requires the players to move in order to play and encourages everyday usage it can impact the users' health positively.

The similarities between Pokémon GO and the application in this thesis are that they are mobile games that have the users walk to different GPS locations to earn points. The games also take steps into account since the users can walk a certain amount of steps in order to get an egg in Pokémon GO. Both applications take health and movement into account. A difference between them is that Pokemén GO is used as a leisure application and not for educational purposes.

2.3.3 Quiz applications that encourage physical activity

Quiz applications have also been combined with games that encourage physical activity. An example of such an application is Active quiz which is an application that, when the users begin to walk, starts a quiz as entertainment for the walk [24]. The application is developed by a company called Trilo Interactive AB. Trilo has previously developed applications with a focus on pedagogy. The idea for Active Quiz was to develop an application that was both fun and pedagogic but was not specified to a definitive line or place.

Active Quiz has three main areas; schools, care and companies [25]. Trilo wanted an application that was dynamic and fun to use but but at the same time make it available for diverse companies to use it during events. Anyone can create a quiz which will not be dependent on where the participants will walk.

The main problem they wanted to solve with this application is to make it possible to create a quiz that is not dependent on where the users will do their walk [24]. They had noticed that most of the related applications were dependent on that the quiz was performed in a specific place. As a result, some people could not participate for example people with visual impairments, people in wheelchairs or anyone who has difficulty walking.

Active Quiz has solved a similar problem to this thesis' problem domain. Both concepts are quiz games with a focus on physical activity. However, Active Quiz focuses not only on schools but also on care and companies. The quiz game that is being designed in this thesis will have a more narrow focus because the primary target groups are students in middle school and their teachers who create quizzes. Another distinction is that the application can be either step-based or GPS based while Active Quiz is delimited to step based.

2.3.4 Digital tool for school assessment and communication

A quiz game can provide valuable information and statistics to teachers about their students' studies. It can also be used for school assessment and communication if im-

plemented right. Communication is key in successful relationships between students and teachers. Communicate information to students and create a good environment for feedback and encourage students to ask questions is important [26]. Technology and digital tools have given teachers and students new ways to communicate efficiently.

An example of a tool for school communication and education is Google Classroom which is a tool that Google has developed in cooperation with teachers. The tool is a support for teachers where they can create classes in which they can manage school assignments, send feedback and get a good overview in the same place [27]. Google Classroom provides a better organization, the students can see their assignments and materials in different folders. The tool increases the quality of communication and feedback and teachers can send messages and start discussions in the classroom. Students can share resources with each other and cooperate in the classroom. The guardians can receive a summary of the students' work via e-mail [27]. The summary includes information about missing and upcoming school assignments and course activities.

3

Theory

In the following section, the theory of the thesis will be described, including theoretical frameworks and relevant concepts. Related research will also be narrated.

3.1 Research through design

The human-computer-interaction community has for years struggled with integrating design into research [28], but it has been shown that research through design in interaction design has given valuable knowledge about the research itself. The design process is recognized by research through design as a legitimate research activity [29]. Research through design is integrating models and theories with technology in the design process. Instead of gaining knowledge from studies, studies of design in use generate knowledge.

Two basic stances exist towards design one is based on intuitions and one is based on evidence [30]. Designs based on intuition may imitate earlier working solutions for specific cases and takes no deeper consideration than what has worked before. Even if these kinds of designs necessarily are not bad, they sometimes do not meet modern demands and are not cost-efficient. Therefore designs based on intuitions have been replaced with a more scientific design approach. Design based on scientific evidence when making design decisions is called explanatory or evidence-based design. To make explanatory design the designer has to answer *why* and *how* questions. In order to do this, the designer should look at scientific knowledge and empirical findings. If these can not be found the designer should do empirical analyses or search for alternative solutions.

The modern goal is that design is based on scientific evidence and not on intuition. But it is hard to achieve in design research. Gaver states that there is always a *sometimes* implicit in statements on how to design successfully, no matter how the researcher defines success [31]. This makes design theory unfalsifiable since even if a theory is proved unsuccessful ten times the next test can always become successful. Research hypothesis in science is often proven true or false by trying to show that they are false because only confirmation of a theory should not be considered proof of it. This makes design research problematic since it can not typically be falsified. Gaver argues that design research can not be changed in order to have falsifiable statements. Because falsifiable statements would fight against the methodological approach toward research in design since design and design research is generative.

Therefore instead of having a research statement which is *what is* the statements should be written *what might be* or similar.

3.2 Design thinking

The design thinking process is a model constructed on the basis of experimental studies at the beginning of the 2000s [32]. A simplified version of the design thinking can be described as a conversion process, that starts with a description of a goal and ends of a representation of this goal in form [33]. The model of the process consists of five steps shown in *Figure 3.1*.

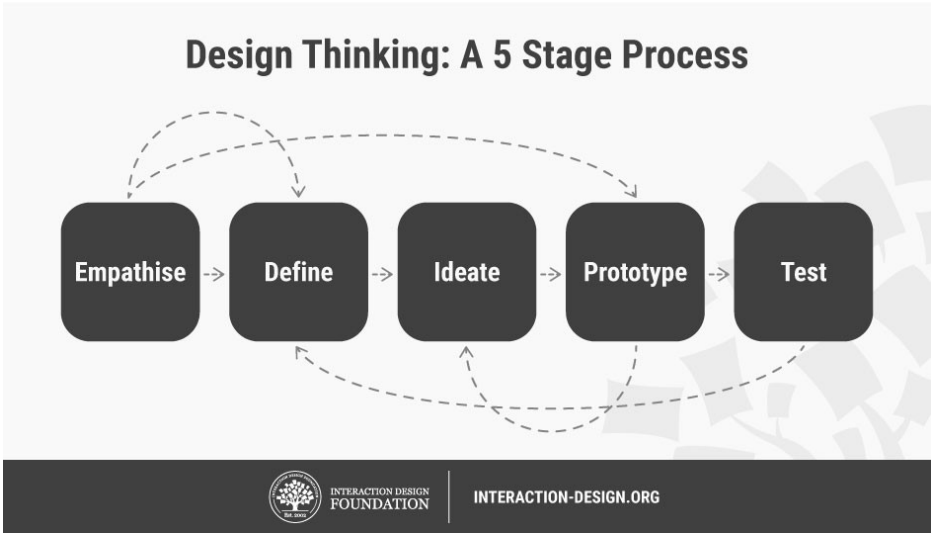

Figure 3.1: A model of the design thinking process [34].

Empathise

The first step, empathise, is about understanding and observing people and the problem. The goal is to get clues about the relationship between the problem and the context and also find hidden needs from the users. It is called empathise because empathise is the competence to recognize the feelings and thoughts of people.

Define

After empathising the designer has to define the problem. In order to solve a problem, the problem and context have to be defined. The information gathered from the empathise phase has to be condensed and synthesized in the define step. The define step involves critical thinking and interpretation skills to give a clear view and direction for the next step.

Ideate

The third step in the model is ideate. Ideate is about generating ideas, being open-minded and being imaginative. Brainstorming is often conducted since it helps the team build and develop each other's ideas. The goal with the ideate

step is to transform knowledge about the problem into actionable problem-solving ideas.

Prototype
In the prototype phase the designer experiment in order to make ideas come to life, making the ideas tangible, actionable and testable. While prototyping the designer will learn more about the ideas. Prototypes can also be used to share ideas with others.

Test
The last step of the design thinking process is testing. Testing is important in order to receive feedback about the idea that has come to life through the prototype step. Feedback can come from everyone involved in the problem context. As in the empathise step testing consists of an information gathering. This information is about the solution of the problem and shows how well the problem has been understood. The feedback is important to understand in order to refine the idea.

Even if the design thinking process consists of five steps it does not have to be conducted linear. It can be conducted as a iterative process and the designer can at any moment go back or forth to any step in the process [33] as seen in *Figure 3.1*. For example, from the test step the designer can get insights about the users which will lead the designer back to the define step [35].

3.3 Mobile game interface

A user interface is an interface that enables a user to interact with digital devices, with the use of graphical icons, symbols, menus and user controls [36]. A user interface is manipulated by a pointing device or a finger on a touch screen. The graphical interface has replaced the difficult textual interface that was used in earlier computation with a more pleasant and natural interface [37]. It is also easier to learn than the old textual interfaces.

Making interfaces for mobile games has been argued as being another task than traditional graphical user interfaces. Game design is not just about minimizing the cognitive load of a user with an as simple user interface as possible [15]. Game design is also about designing entertainment, challenges and meaningful experiences. Mobile game design should not just focus on usability but also playability. Therefore when designing a mobile game interface it is important to involve the player early in the process and not design only for usability. Designing mobile games interface differs from other games because mobility has to be taken in to account. Examples of differences between mobile and desktop user interfaces are the space and layout, buttons are not available on mobile devices and image quality of the mobile device [38].

3.4 Health motivation in education

Research has shown that physical activity and six other health disparities influence students' motivations and ability to learn [39]. This may also impact for example academic achievements, absenteeism and dropping out of school.

3.4.1 Students motivation toward physical education

One way of getting students healthier in school which has been used for centuries is physical education. Physical education started already in the 1820s when schools focused on gymnastics, hygiene training and care of the human body [40]. But students are not always positive towards physical education. Silverman and Subramaniam suggest that students attitude, both negative and positive, toward physical education depends partly on their feelings towards the educator [41]. Another aspect of students' attitudes is the curriculum content of physical education. If the curriculum focused on a variety of activities the students tend to be more positive about physical education. A curriculum that emphasises competition has also been shown negative since some students in these cases have encountered unsuccessful experiences. These experiences have for some students evolved in an intense dislike of physical education.

A difference in attitude between genders towards different physical activities has also been noticed according to [41]. Findings have shown that boys were, in general, more positive towards challenging activities that had an element of risk, whereas girls tend to favour physical activities emphasising aesthetics. There has also been found that girls have more positive feelings toward physical activities because of social reasons. Similar attitudes for both genders have been shown for physical activities that aim to release tension.

3.4.2 Promoting health in all education

Because of the health gap [39] between students and that some students tend to not like physical education [41] it is important to incorporate health in other subjects than physical education. Centers for Disease Control and Prevention in the USA have made guidelines on how to promote healthy eating and physical activity in school [42]. These include establishing a school environment and use a coordinated approach that supports healthy eating and physical activity. The guidelines also request to provide a quality school meal, physical education, health education and health services in school. Lastly, they request to employ qualified persons at schools and to partner with families and community members.

One way of promoting health awareness is with engaging gameplay in education. A case study, made in 2008, on 13-16 years old, looked at ways to combine promoting health awareness and engaging gameplay [43]. The study concluded in some implications regarding designing the gameplay. They mentioned that it is valuable to support social aspects in gameplay because the target group both in online games

and multiplayer games seems to be motivated to play by the social factor. When making educational gameplay that promotes health awareness it is important to interweave the education in engaging gameplay. They also found that mobile games that promote health awareness should be easy to learn and approachable. It would also be beneficial to connect the gaming with choices in real life and have challenging tasks and features that provide feedback and improvements.

Nudging has also been seen beneficial when promoting health-related goals [44] and is today, to some extent, used in education [45]. Nudging is a method to solve problems by steering people in different directions [44]. The method is to direct the persons but still letting them preserve their liberty to choose themselves in which direction to go. Nudging has become more popular to use since it has generally low cost and can have the potential to promote for instance economic goals and health-related goals. Examples of nudging are GPS, alarm clocks and graphic warning for cigarettes. All the examples steer people in a direction but it is up to the person itself to choose the direction [44]. An example of nudging that has shown positive effects in schools is having frequent exams or tests [45].

3.5 Games in education

It has been found that students learn better when they want to learn because only then they develop an interest in the subject [46]. Therefore it is important to engage students in education.

3.5.1 Gamification in education

Research has been done to investigate students' perceptions of gamification and game elements in learning [47]. In this research, a questionnaire was sent out to students were the questions where about their perception of gamification and game elements in learning. The results were that the majority of students had a positive attitude towards gamification in education and that it would improve the learning environment and make it more interesting. The game elements were investigated based on usefulness. The students rated the game elements points, leader boards, profile, teams, progress bars and badges. The result showed that the students were positive against all game elements regarding their usefulness to make a system more enjoyable.

Research has been made on how to use gamification to engage students in school in educational elements. It has been found that using game-based heuristics for example GameFlow [48] has a higher engagement [49]. Dicheva et al.[50] have studied in what educational context gamification has been applied and what game elements that have been utilized in gamifying educational systems. Their study was a research review and they found several educational gamification design principles. The design principles concerned goals, challenges, quests, customization, progress, feedback, competition, cooperation, freedom to fail, storytelling and onboarding.

3.5.2 Designing engaging education

When designing fun and educational games Bruckman suggest that the designer should make the learning inherently fun, put learning in context, use open-ended tasks, learn things in a useful approach and provide social support for learning [46].

A framework formed by Lee describes engaging pedagogical patterns and connect them to interaction design [51]. The interaction patterns presented are triggering, conveyance, exploration, enriching, supportive, constructive, integration and resolution interactions. The framework is still just in development and needs further work in order to become a reference model. Another study made with 613 students [52] has seen that peer interactions, student autonomy and inclusively have increased students' engaged behaviour. The study has mostly seen more social and active engagement. Autonomy support and structure have also been seen positive when engaging students in learning activities [53].

4
Methodology

This chapter presents methods that can be used when conducting research and during the design process.

4.1 Prestudy

In this section methods to use when conducting a prestudy will be presented.

4.1.1 Literature review

Literature reviews are not only useful for academic papers but also for design projects [29]. A literature review is used to collect research about a topic and synthesis of the research. Literature reviews should not summarize everything from a research but rather draw connections between sources and hold the focus on the design project in order to be relevant. The collected literature should be used for developing questions for stakeholders and act as additional domain knowledge to check against collected data [54].

4.1.2 Benchmarking

Benchmarking is about comparing projects with the project you are working on in order to get prior knowledge about the domain [55]. It is important in order to improve the performance of a project. The advantages of benchmarking are that it is a short cut in the improvement process and it can be helpful when solving problems. The basic idea of benchmarking is to first define the project and area of the problem. Secondly, find projects and organizations that do similar projects better than you can do them. Thirdly find out what they are doing that makes them better than your project and finally, adapt and adopt their practices.

4.2 Empathise

During the empathise phase user research is usually carried out. Four user research methods; interviewing, focus group, observation and shadowing are described in this section.

4.2.1 Interviewing

A user research method is interviewing, which is one of the fundamental survey research methods, where questionnaire is the other [29]. An interview is a great method for direct contact with users and can lead to insights about the users' experiences, opinions, perceptions and attitudes. Interviews are often carried out utilizing complementary methods such as questionnaires and observations. Depending on the purpose of the interview, they can be designed differently. There are three types of interviews; unstructured, semi-structured and structured [56]. In an unstructured interview, the interviewer has no predetermined set of questions but instead asks some broad questions trying to start a discussion. This type of interview is mostly used when the interviewer wants to get the stories behind the interviewees' experiences and when there is little knowledge about the topic. In a semi-structured interview, there are predetermined questions but the interviewer is also allowed to ask follow-up questions when an interesting topic comes up. Semi-structured interviews are usually used when the purpose is to collect in-depth information from several interviewees in a systematic manner. In structured interviews, predetermined questions are asked in a predefined order. The interviewee is given a set of options to choose among when answering the questions. This type of interview is usually used in surveys.

According to Cooper, there are six main topics to consider when formulating interview questions aimed for users; The context in which the application fits into the life or work of the user, when and how the application would be used, the domain knowledge from the user's perspective, currents tasks and activities, goals for utilizing the application, the mental model and problems or frustrations with current applications [54].

When assessing children's behavior it has been suggested to first identify problem behaviour with a thorough clinical interview [57]. When interviewing teachers, planning is of great importance and it is crucial to reflect on what information to gather from the interview [58]. It has been noticed that children often are happy to answer easy questions such as birthdays, favourite computer games and favourite subjects or sports [57].

4.2.2 Focus groups

Focus group is a research method which means that a group of well-chosen people sits down together and talks about a problem. Focus groups can give good insights about a problem if moderated right [29]. If the moderator does not have great skills in moderating it can be hard to get good insights. Another negative aspect of focus groups is that it is not taken place in the location of the problem. For example, a focus group with students and teachers would not take place in a classroom but rather in a meeting room.

4.2.3 Observation

Observation is a method for understanding behaviours and situations through attentive looking [29]. Observations can have a different focus where people, behaviours and interactions are some examples. Advantages with observation are to see how people use something in real environments and it has high validity since the people often do not know they are being observed [9].

Schools provide a useful, controlled setting for evaluating children's behaviour [57]. Observations at schools offer several advantages compared to clinical studies. They are good because they occur in the natural environment. Observing children at schools has also been proven better than letting parents and teachers predict children's behaviour.

4.2.4 Shadowing

Shadowing is used for getting insights about participants' activities and design choices [29]. Shadowing is an observation method and gives qualitative data about users' behaviours. It can arise ethical issues with shadowing if a person is shadowed without consent. It has been seen that shadowing gives an extra layer of data than traditional interviews and observations [59]. Shadowing makes the designer understand not only the mechanism but also the motivation of the user for its behaviour and actions.

4.3 Define

Both quantitative and qualitative data can be gathered from the empathise phase. In the define phase this data should be analysed. It is important to collect both quantitative and qualitative data since qualitative data gives deeper insight into the problem [60] and quantitative data reveals if the insights occur for several people [57]. Thematic analysis is used for analysing qualitative data, for example transcribed interviews [61]. This analysis method organizes collected data to gain a better understanding of the patterns and themes in the data set. Affinity diagramming is an example of a thematic analysis method that can be used in the define phase. Other methods that can be used in the define phase are user journey mapping and personas.

When analysing children's behaviour in school it is suggested to first define target behaviour [57]. Secondly, events should be defined that are related to the target behaviours and these should then be assessed.

4.3.1 Affinity diagramming

One type of thematic analysis is affinity diagramming which is an analysing method with the purpose to cluster observations and insights from research [29]. A model of affinity diagramming is shown in *Figure 4.1*. Affinity diagramming requires some

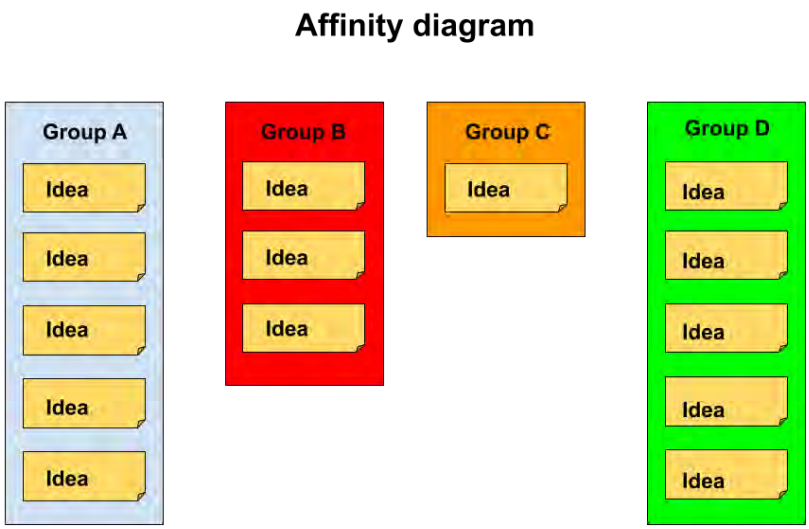

Figure 4.1: A model of affinity diagramming.

sticky notes, some physical space or a whiteboard and a group of people. The first step in affinity diagramming is to transfer data, insights and observations onto post-its and put them up on a wall or a whiteboard [62]. Thereafter one of the post-it notes will be chosen to be the first post-it note in the first group [35]. The group will then continue by looking at another post-it note and compare it to the first one. If they are similar they will be put in the same group or if they are different the second post-it note will create a new group. This is repeated until all post-it notes have been discussed and either put into existing groups or created new groups of data. To easier discover themes the clusters of data should be named. If some groups have similar themes they can be put together and a supergroup label can be created to represent these similar themes. Finally, the group should have a discussion around the diagram, any disagreements or surprises should be reviewed [62]. One of the main benefits of affinity diagramming is that it is a structured way of organizing large amounts of data.

4.3.2 User Journey Mapping

A user journey map is a visualization of a person's experiences when interacting with a product [29]. This allows each moment to be individually evaluated. A user journey map can aid an organization to shift its focus from a system-centered view to a broader context in which the product is used in the real world. This method can also help design teams notice moments that evoke strong emotional reactions in individuals which can be improved and redesigned.

4.3.3 Personas

The concept of personas was first introduced by Alan Cooper and is a representation of users with similar characteristics and behaviours [63]. A persona should be based on real data such as interviews and is often presented in a one-page long description of the goals and personal life of the persona, including a name for the persona and a photograph [63]. Additionally, one of the great benefits of this method is that the communication about the users is improved.

4.4 Ideate

There are different methods that can be used for ideation. This section will discuss some methods and their advantages and disadvantages.

4.4.1 Brainstorming

Brainstorming is often conducted during the ideate phase since ideation should open the mindset of a person [33]. Brainstorming is often viewed as an easy way to generate ideas but in reality, brainstorming is often complex and has flaws since it is not self-evident [64]. Brainstorming is conducted in a group of people and a theme or problem is posed, which all group members will generate ideas or solutions to. Afterward, a discussion is held in the group around the generated ideas and solutions.

4.4.2 Brainwriting

Brainwriting is a variation of brainstorming that can be used for generating ideas [64]. In brainwriting a problem is written on a paper and then ideas and solutions to that problem is written on the same paper. The paper is then passed on to the next person who will read the written ideas and continue developing the ideas. Since brainwriting is a method where the people involved develop each other's ideas this becomes more generative which Gaver states that design and design research should be [31]. Brainwriting is easier to use with fewer people involved and where no one has strong facilitation skills. It is also beneficial to use when time is limited. [64].

4.4.3 Braindrawing

Braindrawing is a method typically used for generating ideas when working with graphical user interfaces [64]. When braindrawing sketches are often made in order to generate ideas instead of writing ideas as in brainwriting and brainstorming. Goldschmidt considers sketches as representations of designers' and architects' 'visual thinking' [65]. Sketches are an important tool in showing the thinking process between designers. Braindrawing is useful for visualizing design concepts and elicit ideas that would not have been shown with traditional brainstorming [64]. After braindrawing voting is often conducted to decide the best ideas.

4.4.3.1 Crazy 8

One method that can be use when braindrawing is Crazy 8. This is a fast sketching exercise that challenges people to sketch eight different ideas during a limited time span [66]. The goal with crazy 8 is to generate a wide range of ideas and be more creative than the first idea on the paper that is typically the least creative one. The sketches do not have to be perfect but should communicate the ideas. Crazy 8 is a good method to avoid being self-critic and to generate a lot of different and creative ideas.

4.4.3.2 Sketching

Goldschmidt considers sketches as representations of designers' and architects' 'visual thinking' [65] and is often used at the beginning of the design phase. According to Benyon sketching is good for generating ideas and showing them to colleagues but they are not good to show for clients [67]. Another problem with sketching on paper is that paper is not robust. It could be very hard for a user to test it and the prototype could break. Complex prototypes are also hard to visualize as sketches.

4.4.4 Voting

When ideas have been generated in the ideate phase, voting is often conducted in order to decide which ideas to move forward with. There are different voting methods which will be described in this section. The aim of voting is to spot potential winning ideas or combinations of attributes from different ideas [68].

4.4.4.1 Dot voting

Dot voting is a very simple technique to use in order to prioritize and making fast decisions [69]. Dot voting is good because it works for all kinds of situations. When dot voting all team members have a decided number of dots that are placed on the different alternatives. The alternatives with most dots are the winners of the voting. Potential disadvantages with dot voting are that a group can get influenced by one person that expresses their voting loudly or there is an even split between the two most voted options.

4.4.4.2 Four Categories Method

In the Four Categories Method the ideas are ranked and voted on in four different categories to cover all grounds of potential winning ideas. These categories are: the most rational choice, the most likely to delight, the darling and the long shot [68]. The method ensures that the most practical ideas to the most innovative ideas are not forgotten. When using this method the team votes on ideas for all four categories and afterward a discussion is held to come up with a winning idea or a combination of ideas.

4.5 Prototype

Prototypes are used to show, explore and represent different states of an evolving design [70]. A prototype is anything that demonstrates a future artifact or just an aspect of it. This section will describe some methods that can be used when prototyping.

4.5.1 Low fidelity and high fidelity prototypes

When designing a prototype it is important to iterate and try different prototype styles and materials in order to show and ideate on different aspects of an idea [70]. It is often preferred and most efficient to begin with low fidelity prototypes and evaluate and test them and then continue with a more high fidelity prototype. An example of a screen-based low fidelity prototype and high fidelity prototype is shown in *Figure 4.2*. According to Hartson and Pyla low fidelity prototypes are most appropriate to use in the prototype step of the design process since they are flexible and easy to change [71]. High fidelity prototypes are better suited for detailed evaluations and as a final design.

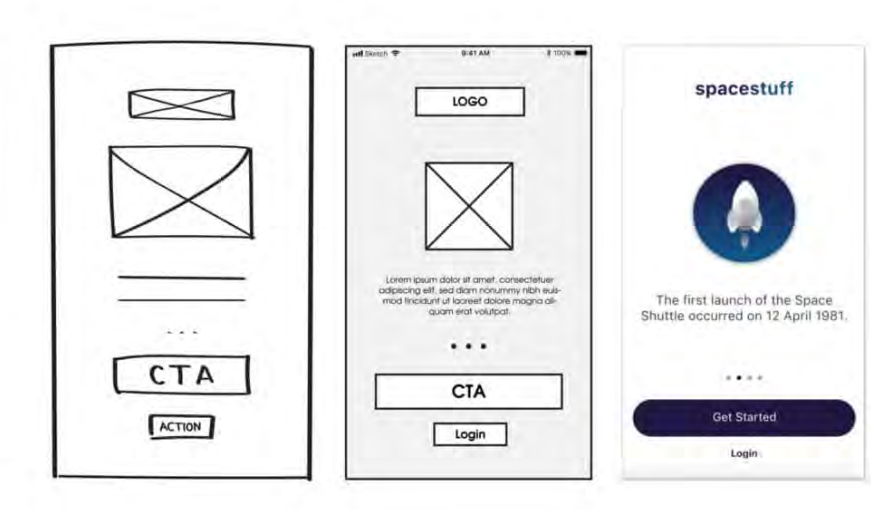

Figure 4.2: Screen-based prototypes with different levels of fidelity [72].

4.5.2 Parallel prototyping

Parallel prototyping can be used to explore different ideas. It is usually conducted by simultaneously making a lot of different low fidelity prototypes [29], for example, sketches. Afterwards, one of the ideas may be chosen by voting or some of the ideas could be merged together into one.

4.5.3 Screen-based prototyping

A good prototyping technique should allow rapid and easy modification [67]. Using screen-based prototyping is a fast prototyping technique and can give designers early

feedback from stakeholders and users, which will ensure the quality of the project [73].

4.5.3.1 Digital tool for prototyping

Figma is a free, collaborative web design tool and can be used in a web browser [74]. Figma can be used for UI design, UX design, prototyping, wireframing, brainstorming, templates and graphic design. Since it can be used for collaborative work it is becoming popular by web designers [75]. Figma allows the prototypes to be previewed both in editable mode and non-editable mode. This has had a great impact on, for example, students because they can easily share their work in a non-editable mode with teachers or future employers.

Adobe XD is another platform for creating designs such as graphical user interfaces for websites and mobile applications [76]. The tool allows the design team to co-edit, create interactive prototypes and share the prototypes. Adobe XD is a desktop application that can be used free of charge but to be able to use it to its fullest it requires a monthly fee.

4.5.3.2 Look and feel

Look and feel is a concept about aspects of user interfaces introduced in 1985 [77]. This concept is usually considered when doing screen-based prototyping. The look in look and feel refers to the appearance of what the prototype displays. This includes the visual layout of words displayed and pictorial features. The other part of the concept, feel, is referring to how programs interact with the user when performing functions.

4.6 Test

This section will describe methods that can be uses when testing a prototype or a product. Furthermore, it will discuss the advantages and disadvantages of these methods.

4.6.1 Usability testing

When testing a product usability testing can be utilized. The intended purpose of usability testing is to check if a product meets its intended purpose [9]. Usability testing focuses on the user and their tasks with the interface and is taken place where the user would normally do their tasks. A problem discovered during usability testing is true if only one user encounters one problem [78].

Middle school students are very easy to include in usability testing [79]. Usability testing with children gives a lot of important insights into navigation and productivity in digital products. Most middle school students are used to do tasks and are comfortable with computers. When testing with students the same preparations as

with adults should be performed but with some alterations. The instructions should be simplified and the duration of the test should be shorter because of the attention and energy span of children.

4.6.1.1 Think-aloud Protocol

The think-aloud protocol is a method that can be used when a user completes a task or in combination with another usability test method. The method requires the user to verbally express what they are doing and feeling while completing the task [29]. The purpose of the method is to discover aspects of an interface that frustrates, surprises, confuses or delights the user. In studies, it has been seen that some middle school students are able to apply the method in usability testing, while others are shyer and do not want to talk as much while being observed [79].

4.6.2 Heuristic evaluation

Heuristic evaluation is a method where expert evaluators look at a graphical interface and are asked to detect problems [80]. It has been found that if an evaluator is doing a heuristic evaluation by themselves they have a hard time finding usability problems, however, if 3-5 evaluators do the same evaluation the statistics become better. The advantages of this method are that it can be done at the workspace and takes less time. The disadvantages are that this method does not involve real users of the product and is not performed in the right context. Problems discovered in a heuristic evaluation are only potential problems since the evaluator does not know for sure that the real user will have that problem, they can only detect problems based on their knowledge and opinions [78]. In the early stages of development, it has been found that 50 percent of heuristic problems are false and 50 percent true. In studies it has been seen that children can do heuristic evaluation but they have problems finding problems in the design [81].

4.6.2.1 Playability heuristics for mobile games

When evaluating mobile games, traditional usability heuristics lack comprehension and cannot be directly applied [16]. Korhonen has made a model with playability heuristics designed for mobile games concerning the three groups Game Usability, Mobility and Gameplay. Examples of these heuristics are: the game contains help, the game gives feedback on the players' actions, the game and play sessions can be started quickly, the players are rewarded and rewards are meaningful and the player sees the progress in the game and can compare the results.

4.6.3 Customer satisfaction score

Due to emotional change, usability testing is not sufficient when testing satisfaction [82]. To gather quantitative data about satisfaction customer satisfaction scores can be used [83]. It is a method that collects quantitative data with numbers rating from, for example, 1 to 5 about customers' satisfaction with a product. The

customer satisfaction score is being used directly after the product has been used. When testing students' satisfaction of school related topics there are often only yes or no questions [84]. But it has been seen that even if these questions are simple and easy to analyse, the students do not reflect on their experiences so much in these kinds of questionnaires.

Studies have shown that cultural difference between test participants can have an impact on how they answer a customer satisfaction score with numbers [85]. To be more robust towards cultural differences in customer satisfaction scores, a survey using emojis can be used. These surveys are more suited for capturing service quality, since they are very direct. An example of such as survey is shown in *Figure 4.3*. An advantage with customer satisfaction scores is that they give quantitative and direct data, while a disadvantage is that satisfaction is hard to measure [83]. Satisfaction is always sentiment and depends on the current mood of the user. A person that is having a bad day might not feel satisfied by a product even if the product did everything right because the experience was still bad for the person. Additionally, the customer satisfaction score can not detect if a person uses sarcasm since the only data that is collected is the emojis.

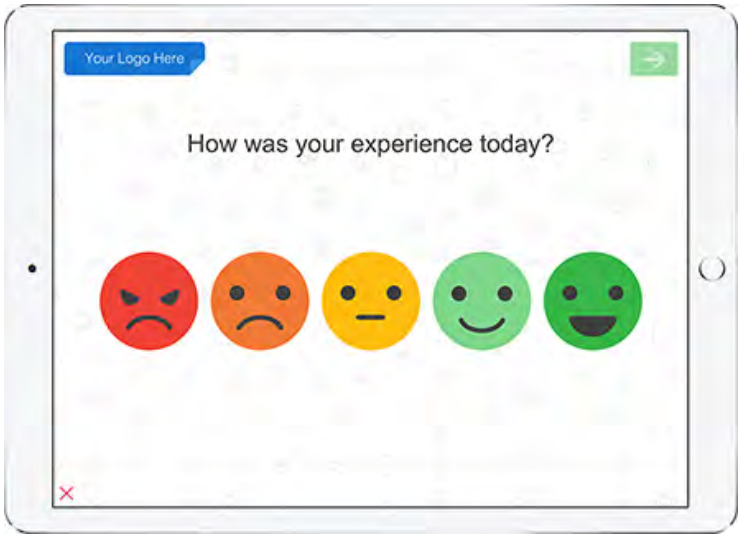

Figure 4.3: An example of a customer satisfaction score using emojis [86].

5
Planning

This thesis will consist of three phases. In **Phase 1** a prestudy will be conducted. In **Phase 2** the design process will be performed to not base the design in intuition. **Phase 3** consists of the last four weeks, finalizing the thesis and prepare a presentation for *Semcon* and *Chalmers*. The master thesis will be written continuously during all phases but mostly in the last phase. The first preliminary timetable made for the thesis proposal is shown in *Appendix A*. A refined timetable for the planning report of the master thesis is shown in *Appendix B*.

5.1 Phase 1 - Prestudy & planning

Phase 1 will involve the first four weeks. These weeks will include getting introduced to *Semcon*, meeting the project team that has worked on the project before and stakeholder meetings. A prestudy will be conducted with a focus on methods and theories that are relevant for the project using a literature review. Benchmarking will also be made to compare the concept in this theses to other applications. During this phase, a planning report will be written.

5.2 Phase 2 - Design process

Phase 2 will involve weeks 5 to 14 and consist of an iterative process of the design thinking process.

5.2.1 Empathise

In the empathise phase interviews will be performed. The project has contacts from three schools, one in Lindängen, Malmö and two in Gothenburg. This master thesis project will mainly work with the schools in Gothenburg due to the time limit of the project and the cost to travel to Malmö. Observation and shadowing will be performed to get a better understanding of how teaching is performed today and how the application can be used to combine physical activity with an engaging educational quiz.

The interviews are planned to be performed with a couple of teachers from both schools in Gothenburg. Shadowing and observation of the teachers will be performed during a couple of hours in two different classes. The goal is to, from the interviews, gather data about how the teachers use games today in education and what statistics

the teachers want from quizzes. From the observations and shadowing the goal is to get more information about how students and teachers work today and how digital tools are used in education. It will also be observed and asked if the teachers use any health motivated methods during class. If the parents, teachers and students give consent, short interviews with students at the schools will be conducted. The parents also have to give consent for observation and shadowing of their child. The interview questions for students will then focus on game activities in and outside of school to get insights about which game activities is preferred by the user group.

5.2.2 Define

In the define phase, the data gathered in the empathise phase will be defined in a problem definition. To analyse the data the method affinity diagramming will be used. Personas will be made as a tool to understand the users' goals and motivations. User journey mapping will also be made to understand a day in the school of different users. These methods will hopefully make it easier to understand the problem area and give a foundation for the ideate phase.

5.2.3 Ideate

To ideate, brainstorming and brainwriting will be conducted to generate a lot of ideas. To show the ideas in a more visual way braindrawing will be performed. The ideate phase will provide different ideas that will be used for the prototyping stage.

5.2.4 Prototype

In the prototyping step, sketching will be used to do fast and low fidelity prototypes. Parallel prototyping will be used to make several sketches that will be discussed and ranked. The sketches will be merged into one, with ideas from the highest-ranked sketches. These will be sketched into a low fidelity prototype. To make this prototype more robust, screen-based prototyping will be used. The low fidelity prototype will focus on the flow and navigation of the application whereas the final prototype will consider look and feel, including colours and visual layouts.

5.2.5 Test

In the test phase, the prototype will be tested and evaluated with usability testing and a customer satisfaction score survey using emojis in the schools with students. Both the usability, satisfaction and how effective and engaging the design is will be evaluated. Teachers will also test the prototype to see if the application is helpful when making quizzes and showing statistics.

5.2.6 Iterate

The design process will be a iterative process which means that during the process, it is possible to iterate back or forth to another phase if needed. However, the different iterations will use the same methodology with some adjustments of methods if they

were not sufficient. The result of the last iteration will be the final prototype that will be a high fidelity prototype. The last test session will test if the goals were accomplished and if the problems were solved.

5.3 Phase 3 - Finalizing report

The last phase of the project will be to finalize the master thesis report. The results will be summarized, discussed and the last writing and editing of the thesis will be conducted. This phase also includes preparations of the presentations both for *Semcon* and *Chalmers* and an opposition of another master thesis will be performed. After the thesis has been presented, feedback from the opposition will be considered in the last revision of the report.

5.4 Ethical Aspects

There are some ethical aspects that could potentially arise in this project. These will be described and discussed in this section.

5.4.1 Accessibility

One ethical aspect that might arise is that the application could potentially exclude students with physical disabilities that prohibit them to walk long distances. However, teachers choose the path themselves and can be aware of where and what terrain he or she creates the quiz. But it can happen that the teacher is not aware of what type of terrain the walking path will have. If a student, sitting in a wheelchair, is doing the quiz it can be hard for that student to perform the quiz if the terrain is very muddy and placed, for instance, in the forest. To solve this problem the game can be adjusted to show which kinds of terrain that it not suitable with wheelchairs or give examples on routes with good terrains. It is not in the scope of the project to test accessibility issues, which could also lead to more ethical issues. For example, users with vision difficulties could have difficulties using the application.

5.4.2 Languages

Another ethical aspect is the language of the application. The language has to be taken into consideration since if it is in Swedish everybody might not be able to understand it, for example, newly arrived immigrants. This could lead to divisions in the learning outcomes between students. To solve this problem more languages could be implemented in the application. Another solution could be that students that have trouble with languages or to read could walk with someone that can translate or explain the questions.

5.4.3 Access to a digital platforms

This concept takes for granted that all students in the class have access to a smartphone. If a student does not have a smartphone they will be excluded. This is something the teachers will have to consider and investigate before using it. Additionally, the prototype is currently built for Android and not for iOS which will exclude the ones having an iPhone. It does not work with iPad's right now so the schools can not borrow out iPad's to students. However, the plan is to develop the application for multiple platforms. This issue will not affect this master thesis project since only a prototype will be designed and tested. But in the future when developing the application it should be considered to implement it for multiple platforms.

5.4.4 Cheating on quizzes

If teachers would use the application for tests in school it can arise an ethical issue. If the student is moving outdoors alone or in a group of students they can easily cheat on the quiz. Since they use their own phone for the quiz they can quickly google the answers or use their calculator. If the students are moving in groups, which could be preferred by the students, it may happen that one student is answering the questions and the other copies the answer. In the case of cheating or copying the students will not learn as much and the educational part of the application will be disrupted. If the teacher uses the application for assessments the result and statistics will give the teacher a wrong perception if the students' knowledge. This ethical problem will be addressed during interviews with teachers.

5.4.5 Moving with vehicles

The quiz can be either location-based or step-based. One problem with a location-based quiz is that it does not know if the students are actually moving by themselves. The questions appear when the user is at a certain GPS location. If a student does not want to walk it could take a bus, rent an electric scooter or bike to the different locations. If the user is riding a bike it is still doing physical activity which means that the health aspect of the application will still be there. But if the user uses an electric scooter or another vehicle the student will not get the physical activity. This ethical problem does not arise with the step-based mood since the phone will not register steps if the user is not walking or running. The problem could arise if the quiz has a long distance but if the quiz is based around the school or in the forest it will be easier to prevent. To counteract this problem the application could show where there are forest rounds.

6
Execution and Process

This chapter presents a sequential summary of how the project was executed and proceeded. First, a prestudy was conducted which included stakeholder meetings, benchmarking, a literature review and planning of methods. Thereafter, the design process began which included three design iterations.

6.1 Prestudy & planning

The first four weeks of the thesis consisted of start-up meetings and stakeholder meetings. Moreover, a prestudy and planning of the project were conducted. Additionally, a review of potential methods to use in the thesis was performed.

6.1.1 Stakeholder meetings

A startup meeting with *Semcon* was held at the beginning of the project. The project team that had previously worked on the project attended the meeting. During this meeting, it was discussed what had previously been done in the project and what our vision and research question was. It was also discussed whether this thesis would include implementing the application. However, since the scope of the thesis is to improve the overall user experience and execute it thoroughly we decided that implementing the application will not be part of the thesis. The end result will be a high fidelity prototype.

6.1.2 Prestudy

A simplified version of the method benchmarking was conducted in order to study related work. Similarities and differences in, for example, user groups and features were studied between the concept in this thesis and other applications and tools. The backlog and the documentation from the previous work from the project was studied.

A literature review of the research areas was made and summarized in the theory. The different research areas were game elements in education, how to design engaging education, how to motivate health with games, how to motivate health in education and overall health in education. Different design processes were reviewed as well as how different methods can be used in the context of education, especially for teachers and middle school students.

6.1.3 Planning of methods

When research had been done a set of potential methods to use during the project was summarized and a preliminary plan was set. A meeting with *Semcon* was held to receive feedback. Inputs, requirements and ideas were received and suggestions on what to focus on during the user research. The plan had been to focus on the students in the user research, but it was suggested by *Semcon* to also focus on the teachers and try to understand their requirements and needs. The plan was to use interviews to gather qualitative data and observations to gather both qualitative and quantitative data. Additionally, it was decided to perform shadowing since it gives an extra layer of data, it does not only show thoughts and behaviours but also the motivations behind their behaviours.

We planned to use usability testing when testing the prototype since it is a relatively easy test method to use with young students. We discussed whether or not to use heuristic evaluation, but since young students have a hard time identifying problems with heuristic evaluation it was decided to use usability testing. However, usability testing does not test satisfaction and a part of the research question is to make an engaging user experience. Therefore we had to use a method to test the satisfaction. Customer satisfaction score was added to also measure the satisfaction of the experience. One of the user groups are students in middle school and they can have different backgrounds and cultures, therefore it was decided to use the satisfaction score using emojis to make it understandable for everyone.

6.2 Iteration 1

This section presents the process and outcome of the first iteration in the design process.

6.2.1 Empathise

An important aspect of creating a user experience is to understand the users. Information about users' behaviours, problems and goals needs to be collected. To gather this data we held interviews with both students and teachers. We also observed and shadowed teachers and students during classes. This section explains the process of preparing and executing the interviews, observations and shadowing.

6.2.1.1 Preparation of interviews

Semcon had two contacts from two different schools, one in a socioeconomically challenged area and one in a wealthy suburb. They were contacted and a day at each school was planned for conducting interviews. A form was created and sent to the two contacts to receive the parents' consent to interview their child and information was given about how the data gathered would be handled. We also got consent from the teachers we were observing and interviewing. This form can be seen in *Appendix C*.

Semi-structured interviews were used to make the interviews open for follow-up questions and create an environment for discussion rather than follow a strict set of questions. However, a set of questions was prepared in order to keep the interview focused on the right set of topics. The questions were formulated with Cooper's six main topics in consideration to get the most out of the interviews. The interview questions aimed for the teachers can be seen in *Appendix E* and the interview questions aimed for the students can be seen in *Appendix D*.

The questions for the teachers were divided into six parts; introduction, test, game elements, statistics, the scope of use and physical activities. The test part aimed to get a better understanding of how the teachers work today concerning homework tests, tests in school, usage of digital tools and games, assessment of tests and how they motivate the students. The questions about game elements focused more on the concept and their perspective on game elements. The statistics part concerned what kind of statistics the teachers want and use and what feedback they think the students want and benefit from. Scope of use aimed to get insights about how teachers would incorporate such an application in their education and their perspective on collaboration on tests and homework and ideas on how to counteract it. The last part, physical activity, was to find out if they already incorporate physical activity in their education.

The interview questions aimed at the students were about games, physical education, school and home work. For instance, what games they play, if they play any sport and if they like games like Kahoot! and Pokemon GO. The interview focused on the interests of the students. The questions were formulated with the purpose to gain a better understanding of what games and game elements students enjoy and their relation to physical education and games in school contexts. We wanted the interviews with the students to be shorter in an attempt to keep the students' attention throughout the whole interview.

6.2.1.2 Interviews with students

The interviews with students were conducted during two days in the two different schools. The students interviewed at the school in the wealthy suburb were in sixth grade and seven students were interviewed, in groups of two or three. The students at the school in the socioeconomically challenged area were in fourth grade and twelve students were interviewed in groups of three. A figure of the setup of the interviews can be seen in *Figure 6.1*. The interviews lasted ten to twenty minutes per group. Since the interviews were semi-structured a set of questions were asked but the interviews were open for discussions and conversations. The students were asked to answer the questions one by one but it often led to a dynamic conversation between the students and us.

6.2.1.3 Interviews with teachers

The interviews with teachers were conducted during the same days as the interviews with the students and at the two schools. At one school three female teachers

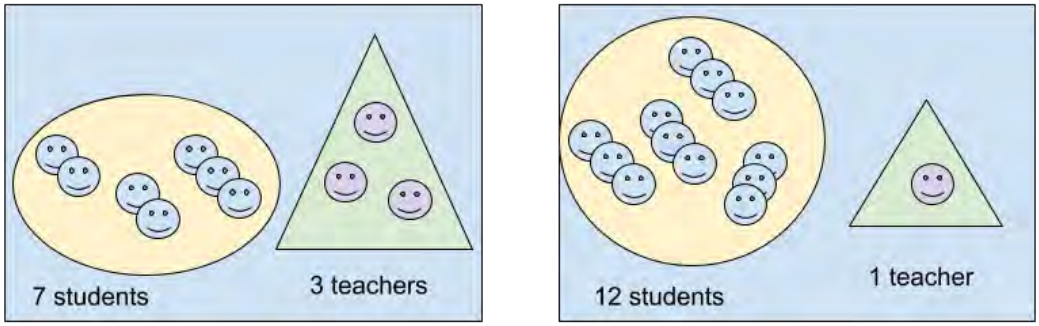

Figure 6.1: A overview of the interview setup at the two schools

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were interviewed, all teaching sixth graders but in different subjects. At the other school, one teacher was interviewed, teaching fourth graders in multiple subjects. The interviews were recorded and conducted individually. The interviews followed the prepared set of questions with alternations depending on their answers. The interviews took fifteen to twenty minutes each depending on how detailed they were in their answers, the number of follow-up questions and if the teacher had a limited amount of time.

6.2.1.4 Observations and shadowing

Observations were performed during three hours in three different classes. During the first class, they went through a test together where the students had to write their solutions on the board. They used no digital tools in this class, besides the projector. The second class was a Swedish class where they looked at a Youtube film and worked in the program OneNote. The third class was English where the students retrieved an exam. They did a Kahoot quiz and had some exercises in the class where they were supposed to walk around in the classroom. The observation and shadowing were conducted simultaneously by sitting in the classroom. Since the students sat close it was easy to hear what they said to their friends in order to conduct shadowing.

6.2.2 Define

In the define phase, the data gathered had to be condensed and synthesized in order to define the problem and the context. To organize the data, the interviews were transcribed. To analyse the data affinity diagramming was used and personas, as well as user journey maps, were created based on the findings from the affinity diagrams.

6.2.2.1 Analyse

To analyse the data affinity diagramming was used. The first step was to read through all the data gathered; the transcribed interviews and the observations. The data were grouped into different classes and teachers. The data that was considered

important and valuable was marked and written on individual sticky-notes. Sticky-notes with different colours were utilized to distinguish the different data groups and interviews. Two different affinity diagrams were formed; one with the data from the interviews with the teachers and the observations and one with data from the interviews with the students. These can be seen in *Figure 6.2*.

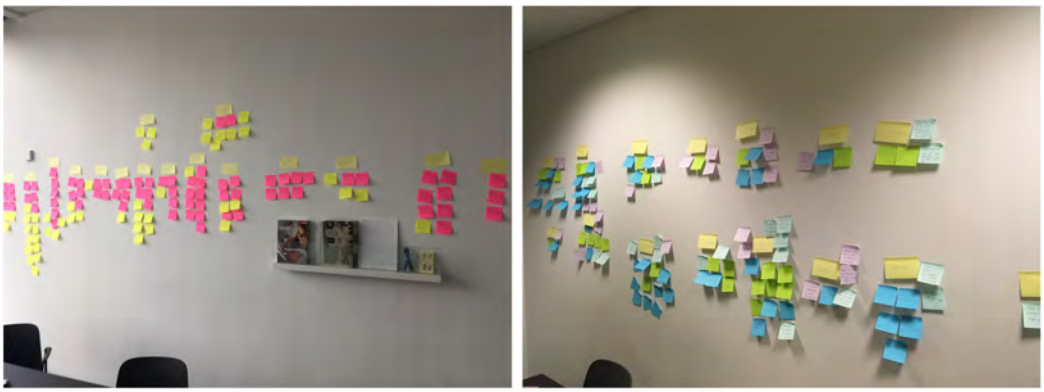

Figure 6.2: The two different affinity diagrams.

The sticky-notes were, one by one, read and discussed. The first sticky-note created the first group. If the next note was similar to that it was placed in the same group or created a base to a new group. This process was executed for all sticky-notes and when all notes were placed the groups were named. If two groups were similar they became subgroups to a supergroup. The sticky-notes and their corresponding group revealed insights, themes and patterns. A discussion was held around the groups and what problems that could be defined. For instance, one group concerned focus because it was found that students need a variety of exercises to keep being focused and that some students are having a hard time focusing. Another group was statistics and that students want to see how many points they got directly and that teachers look at statistics to know what was easy and what was hard for the students. The groups and some example findings can be seen in *Table 6.1*.

6.2.2.2 Personas

Based on the outcome from the affinity diagrams we could distinguish what was appreciated by students and teachers and their frustration. To make the data more condensed personas were made. With the insights in mind, two personas could be distinguished based on the students. The results of the affinity diagram were discussed. The personas were defined based on their goals, needs, motivations, frustrations and wants. Additionally, personality traits, age, name and a representative photograph were defined to make the persona seem more like a real person.

Due to that only four teachers were interviewed, there was only one persona that could be distinguished from the affinity diagram with teachers. The personas made can be seen in *Appendix F*.

Groups	**Finding**	**Finding**
How to create quiz	Differs from classes	Likes to add questions with the computer
Tools for school work	Students and teachers like kahoot! and it is used a lot	The colours and music in Kahoot are liked
Problems with quizzes	A risk with digital quizzes is that it can distract the students	Hard to read statistics when it is answer alternatives
Focus	Students need a variety of exercises	Some students find it hard focusing
Mobile	Ipad version of applications is good	It is okay to use mobiles for this kind of application
Outdoors	Being outdoors can make students unfocused	It is fun to have questions at a specific location
Learning	Sometimes explanations are needed	Good to encourage students
Time limit	Teacher do not have time to give oral feedback	Sometimes teachers need to do preparations at home
Homework	The app works for learning and not examining	Some students do not remember to do to their homework
Cooperation	Teachers prefer that students are doing quizzes in pairs or alone	Students often help their friends which is a learning experience
Statistics	Students want to see how many points they got directly	Teachers want to look at statistics to know what was easy and hard for the students
The functionality of the application	Themes can provide engagement	The students learn more when combined with something fun
Tests	Students like to share their grade	Quizzes on paper can be messy and get lost
Motivation	Variation on exercises can motivate	Competition can motivate

Table 6.1: Findings from the user research.

6.2.2.3 User journey map

Based on the personas, user journey maps were created; one based on the persona who is a student and one based on the persona who is a teacher. A school day or a work day was explained in order to find problems, frustrations and enjoyments of the persona. Their actions are stated and their corresponding satisfaction level during this action. The satisfaction level varies from sad to happy, which is represented by emojis. The user journey map that is based on a student is for example very happy when hanging out with friends and being outside playing football. But in classes, the persona is not as happy due to having a hard time concentrating. The user journey map that is based on the teacher persona is very stressed during a work day but tries to use a variety of tools in the classroom and when it is appreciated the persona gets very happy. The two user journey maps can be seen in *Appendix G*.

6.2.2.4 The discovered patterns and themes

The discovered problems, patterns and themes were defined. For students, these were either related to games, education or both. These can be seen in the lists below.

Game patterns and themes

- Individual choices
- Challenges
- Teamwork
- Game elements
- Action
- Themes
- Variation
- Competition
- Rewards
- Engagement

Educational problems and patterns

- Reminders
- No distractions
- Teamwork
- Learning
- Variation
- Competition

The discovered problems, patterns and themes for teachers can be seen in the list below:

- Reminders
- Statistics
- Learning
- User friendly

- Share and save quizzes

6.2.3 Ideate

After the define phase, including analysis of the data, defining personas, defining user journey maps the ideation phase began. A foundation had been created and an understanding of the user groups was established.

6.2.3.1 Brainstorming

To warm-up, the first step in the ideation phase was a brainstorming session. The brainstorming session was held around the discovered patterns and themes. One at a time, we brainstormed around the theme for two minutes each. During these two minutes, ideas on the themes were written on sticky-notes. The ideas could be a solution, a requirement for the application, or a general thought about the theme.

The outcome of the brainstorming session is summarized in the list below:

- **Individual choices:** Choose an avatar or choose how to look in the game.
- **Reminders:** In the application, the teacher can notify when an exam will be.
- **No distractions:** Notify when a question is visible so the students do not have to look at their phones all the time.
- **Statistics:** Show how many times a student has done a quiz. The statistics should be clear and easy to understand and read.
- **Challenges:** Choose how many alternatives you should have on the quiz or that you need to write the answer to the question yourself.
- **Teamwork:** Do a quiz in pairs and the teacher should know who is in the groups.
- **Game elements:** Different avatars with different voices can appear during the quiz and tell the question. Be an avatar that finds or buys things to the avatar.
- **Learning:** Get more chances to answer the questions. Be able to repeat the questions that were answered incorrectly.
- **Action:** When a quiz is finished you fight against a friend with as many lives equal to the number of correct answers on the quiz.
- **Themes:** A country-based theme. Walk to the moon-theme, where the steps taken are saved and it is visualized how far you have come in the process of reaching the moon.
- **Variation:** Play individually or in teams. Have mini-games inside the game. Events can happen during the quiz which will be different every time you play.
- **User-friendly:** Do not have too many aspects in the application. Be able to edit quizzes. It should be simple to make quizzes.
- **Competition:** A winners' stand. Get points when making a quiz multiple times.
- **Rewards:** Get points. Use motivational words in the application.

- **Share and save quizzes:** Be able to create a group for your class where all the created and saved quizzes are collected for that class. Be able to share quizzes in multiple ways.
- **Engagement:** Show the process. Have rewards. Get the result quickly.

6.2.3.2 Brainwriting

The next step in the ideation phase was to perform brainwriting. Problems identified from the personas and the user journey maps were written down on the top of a paper. The problems identified can be seen in the list below and all these were written on an individual paper.

- How can competition aspects be integrated into the application without having the students compete against each other?
- How can the process of creating a quiz be quicker and easier?
- How can the application integrate more complicated questions?
- How can it be counteracted that students are doing the quiz in too big groups and become unfocused?
- How can the application make it funnier and more motivating to do homework?
- How can the application solve the problem that the students get distracted of other applications on the mobile while using the app?

During two minutes possible solutions to the problem statement were written down on the paper. If a problem statement already had possible solutions written down, those ideas were further developed. This process continued until all problem statements had at least been iterated twice. Thereafter all possible solutions were discussed and documented. Some examples of solutions to the problems were:

- Use animations to show when you had a better result than last time the quiz was performed
- Compete in groups
- Have different distances on the quiz for different students
- Having the questions be read by different voices

6.2.3.3 Braindrawing

The last step that was done in the ideation phase was braindrawing. We used the braindrawing method Crazy 8. Crazy 8 helped us visualize the different ideas that we had generated from the previous ideation steps. It also made us ideate new ideas since we saw things in new perspectives. During the braindrawing we first came up with problems and themes as in the previous ideation step. Then we performed the method Crazy 8. The problems and themes identified can be seen in the list below.

- How does a user add questions?
- How does it look when students do a quiz?

- Statistics
- Game elements
- Profile/avatar

We had eight minutes in total to sketch eight different ideas per problem. A discussion was held after each Crazy 8 iteration and the ideas we liked the most were documented. Some ideas generated during the braindrawing are summarized below:

- **How does a user add questions?**: Insert the name of the quiz, description, category, and if it is a public or private quiz. Add the answer alternatives and indicate which is the right alternative in the same view. Have a summary of the created quiz where you can change the quiz. Be able to import a quiz from other programs like Kahoot!. Be able to record the questions.
- **How does it look when students do a quiz?:** Be able to see the number of questions completed and how many steps walked. Have a winners' stand with the class. Be able to repeat the questions answered incorrectly.
- **Statistics:** The teacher can share statistics. Show statistics with graphs, such as bar charts and circle graphs. Be able to see detailed statistics per student.
- **Game elements:** Find items during the quiz. Get challenges. Compete against one classmate.
- **Profile/avatar:** Choose an avatar and customize it. The avatar begins as a baby and grows bigger depending on how many quizzes the user does. Earn stars when the user has performed a quiz several times.

6.2.4 Prototype

When beginning the prototyping phase we had a list with ideas from the ideation phase. All of these ideas were discussed and the ones we liked the most were summarized in a list of possible requirements. The requirements were not definite but rather ideas that were generated during the ideate phase based on the insights from the user research. The requirements were ideas that we were going to visualize by sketching them. The sketches made up the foundation of the low fidelity prototype.

6.2.4.1 Sketching

Sketching was made individually on paper and a lot of quick sketches of different views were produced using parallel prototyping. The sketches were wireframes with a low level of detail. We discussed the sketches and a second iteration of sketching was performed where we combined the sketches with some changes. For instance, as seen in *Figure 6.3* one change was to move the selection of GPS or steps. If the user would have to choose the path before the questions were created the user would not see where the questions were placed on the map. Therefore we decided that the user would create the questions first and then choose the path or steps, by doing this the user will be able to see where the questions are being placed throughout the path.

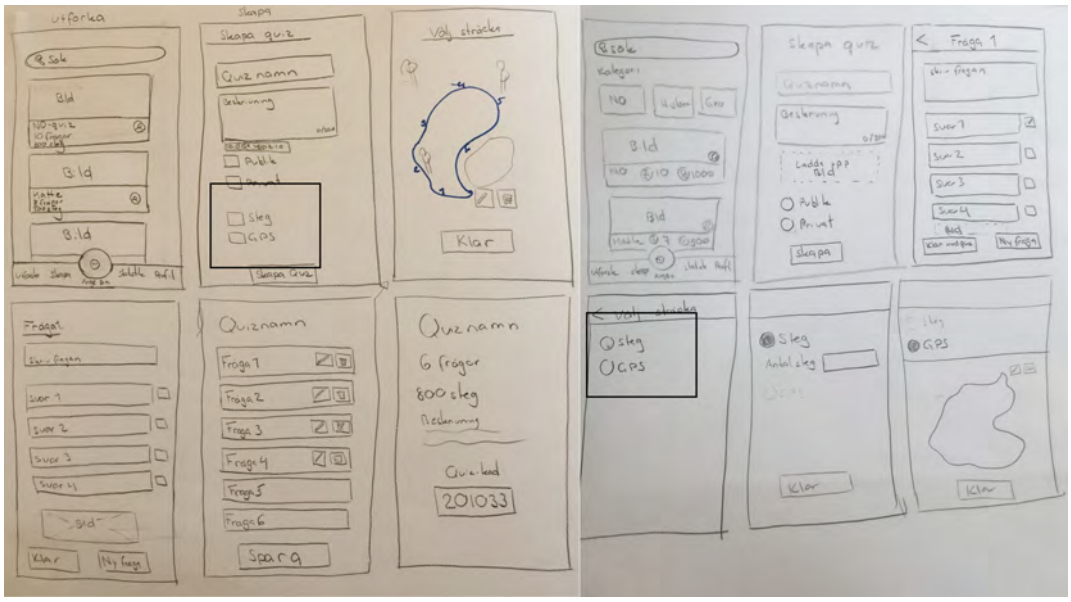

Figure 6.3: An example of a change made when sketching. The left sketch in from the first iteration and the right is from the second iteration.

6.2.4.2 Screen-based prototyping

When we felt that we had a good foundation of the design the next step could be initiated, screen-based prototyping. The free, collaborative web design tool, Figma, described in *Section 4.5.3.1* was used. The main reason for using Figma instead of Adobe XD was that we had previous experience with it and that it is free of charge. It also allowed us to work concurrently on the prototype and efficiently receive feedback due to its intuitive way of sharing prototypes.

There were still some design decisions remaining, for instance, the design of the answer alternatives was not decided. However, we felt we needed to see the alternatives as a screen-based prototype to get a better understand of how it would look like on a real phone. Parallel prototyping was used to prototype different ideas generated from the sketches to later decide which one we wanted to go forward with.

The low fidelity prototype did not focus on colours and details but some colours were added in order to show the ideas better. For example, the statistics and the four answer alternatives. *Figure 6.4* shows three screens of the low fidelity prototype. The main functionalities of this prototype were that you create your own avatar, competing in groups against other groups and that you encounter monsters during quizzes. For example, when questions appear the user is faced with different monsters. If the user answers correctly it can collect items.

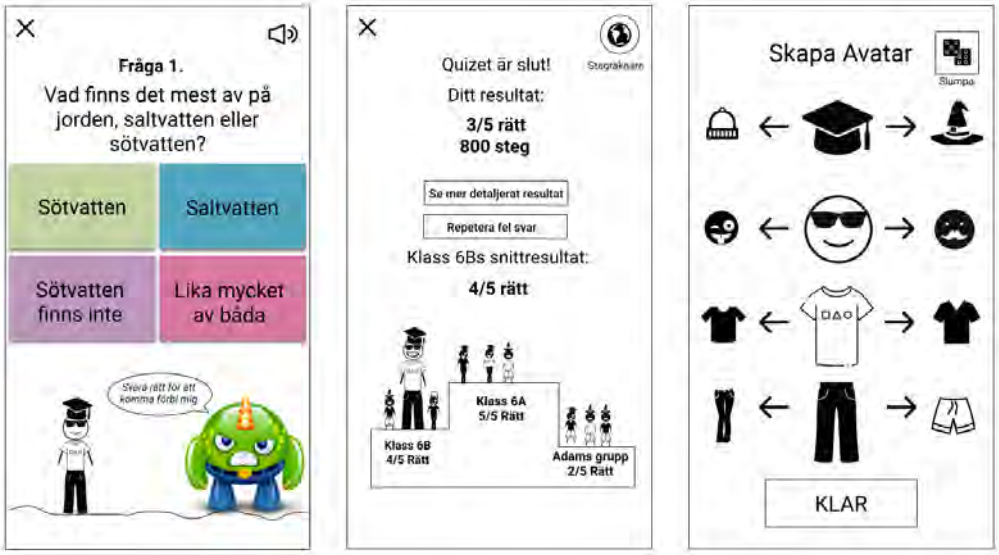

Figure 6.4: Three screens of the low fidelity prototype.

6.2.5 Test

To validate the first low fidelity prototype we prepared two different test setups; one aimed for the students and one aimed for the teachers. This was done to test the different parts of the design. Due to the Covid-19 pandemic, we decided to do the testing digital. We discussed different alternatives on how to best test the prototype with students digital. One alternative that was discussed was to make a video where we show how the application works and then follow-up with a questionnaire with questions related to the design. Another one was having a Skype or facetime call where the students share their screen with us and then we could do usability testing. We decided to do a video where we show the interface and then have the students fill in a questionnaire with questions about the design and what they thought about it. This solution seemed more feasible and easier for students to do. However, we chose to do usability testing with teachers because they may have more experience with, for example, Skype and we had established a good contact with some teachers.

6.2.5.1 Test with students

The decision to make a video describing the application accompanied by a questionnaire came with new challenges. A discussion was held around what parts of the design we wanted to test with students. We wanted to test the game elements, such as creating an avatar and the monsters appearing along with the questions. We also wanted to test the social part of the quiz, that you can play as a group and against other groups. We had to develop the prototype and add more screens to get a good and understandable flow in the video.

The video was made by recording the screen while interacting with the prototype with a voice-over describing the application. The film was retaken several times and

one of the final ideas that were implemented was to show in the film that the user should walk outside during the quiz as an attempt to visualize the whole experience. Physical activity is an important part of the application and it was therefore of great importance to communicate that the application requires the user to walk. The test participants need to get an understanding of the whole experience in order to give good feedback and to answer the questions in the questionnaire.

The questionnaire was made in Google Survey and the questions focused on what game elements and parts of the application that the students liked and disliked. These elements can be seen in the list below:

- The avatar
- Collecting items
- Competing against other groups
- The monsters during the quiz
- The pedometer

A likert scale was used for most of the responses that spanned from "Not good at all" to "Very good". For instance, the first question was if they thought it would be fun to create their own avatar and they had to pick an alternative on the scale. The questions concerning competing against other groups, the monsters and the pedometer were asked in a similar way. Some questions had two answer alternatives. For instance, another question was if they like collecting items to their avatar or if they rather collect points, then they had to choose what they thought was funniest, collecting items for the avatar or collecting points. One open-ended question was included, where the test participants would write one thing they liked and one thing they did not like about the application. The last question was about how they liked the application overall where the answer alternatives were visualized with smileys to measure the satisfaction score of the overall experience. The form was sent to the two teachers, which we had contact with from the interviews, and they sent the form to their students. Another class from a school in the countryside also tested the application. Additionally, a student in second grade tested the application to see if the application could work for younger students.

38 responses were received on the questionnaire and since we used Google Survey, bar charts and circle charts were generated to visualize the data. We analysed the data by going through all questions one by one and identified positive and negative outcomes. All the charts can be seen in *Appendix H*. The main outcomes are summarized below:

- **The avatar:** The students liked the avatar and that they could customize it, however, it was somewhat perceived as boring due to the lack of colors and illustration.
- **Collecting items:** Some would rather collect money or points to buy things for the avatar but the main part of the responses liked that you collect items to your avatar.

- **Competing against other groups:** This aspect was very appreciated and they liked that they could see who else had joined the quiz. The feature of being able to chat in the groups was liked.
- **The monsters during the quiz:** The average response was that the monsters were intermediate and they were perceived as weird, ugly and out of the context.
- **The pedometer:** This aspect was appreciated.

6.2.5.2 Test with teachers

To test the other parts of the design such as creating a quiz, see statistics and create a group we chose to perform usability testing with teachers. These features are the management of quizzes and groups and will probably mostly be used by teachers. We had to do it digital due to the pandemic Covid-19. It was more convenient to do usability testing digital with teachers than with students due to that it was fewer teachers and they probably have more experience in using Skype or similar tool in working related meetings.

The goal of the usability test was to gather qualitative behavioural data and get input on design-related questions. Additionally, the goal was to get insights and feedback about if the content was presented in a way that the teachers found easy to understand. Several tasks were prepared to gather this data. The tasks that were performed during the test are listed below:

- Create a group
- Create a quiz
- See statistics

Two female teachers tested the prototype. One teacher was 46 years old and was a teacher for middle school students, the other teacher was 30 years old and teaches elementary school students. The test participants were asked to think aloud while performing the tasks.

The outcomes from the tests were ranked with low, medium or high priority to reflect their importance. The highest-ranked outcomes from each task are summarized below:

- **Create a group:** It was hard to find where you create a group. Not intuitive that groups and that creation of groups are in the profile. Additionally, the tab bar in the profile was in some cases missed. The aspect that the groups could compete against each other was considered fun but some uncertainty about if it would be more stressful for the students.
- **Create a quiz:** The navigation and process of creating a quiz were easy to understand. However, it was not at first understood what the checkboxes next to the text fields to answer alternatives meant.

- **See statistics:** It was considered logical and easy to find the statistics and see the overview and the detailed view. It was not understood that it was possible to interact with the diagrams to receive more information. Additionally, it was requested to be able to see which questions the student had answered correctly in all of the attempts on the quiz. Last, the labels "Made quizzes" and "My groups" in the first statistics view were not intuitive.

6.2.5.3 Test with adults without teaching experience

Due to that we only did usability testing with two teachers we decided to do usability testing with our friends and families as well. We asked five test participants to perform the same tasks as the teachers. The participants were of different genders, ages and with different technical backgrounds. In order to test if the application could be understood for non-Swedish users, one participant was non-Swedish.

The outcome of this test was somewhat similar to the outcome of the usability test with teachers. For example, it was difficult to find where you create a group, the checkboxes when indicating the right answer was unclear and it was hard to understand how to interact with the graphs. Due to that the outcomes were similar it helped us to prioritize the findings from the test with teachers.

6.3 Iteration 2

This section presents the process and outcome of the second design iteration. When the test results had been analyzed it was realised that we had to go back to the define step and redefine the problems.

6.3.1 Define

Based on the outcome of the testing we could see that there were many aspects of the design that were appreciated but there were also some parts that were not as appreciated which made us go back to the define step to redefine and reformulate the design challenges. The two main problems that were seen were the monsters appearing during a quiz and that it was hard to find where you create a group. The monsters were perceived as weird, ugly and out of the context and the responses can be seen in *Figure 6.5*. This graph shows that the monsters were intermediate and not really appreciated.

The difficulties of creating a group were seen in all of the tests and therefore it was of high priority to change and improve it. From the tests, the aspect that the groups could compete against each other was considered fun but some uncertainty about if it would be more stressful for the students was raised. One suggestion from a teacher was that it would be good to let the students do the quiz several times as practise and then the teachers could create a challenge against another group with the same quiz. In this way, the students get the opportunity to practice before competing which may reduce the stress level. Moreover, the overall phrasing in the application

Figure 6.5: The responses to the question about the monsters appearing during a quiz.

raised some misunderstandings during the testing. The redefined design challenges can be seen in the list below.

- How can the monsters be exchanged or improved?
- How can the group aspect be enhanced?
- How can it be clearer of how to indicate the correct answer when creating a quiz?
- How could the results from all the different attempts be visible?

6.3.2 Ideate

When the new design challenges had been defined we could start ideating around these problems to come up with possible solutions. Both brainwriting and braindrawing were utilized in the ideate phase.

6.3.2.1 Brainwriting

The defined design challenges were used in the brainwriting session. Possible solutions to the stated problems were written down on a paper. When we both had written down solutions to all problems the session was complete. However, the problem with the monsters was not included in the brainwriting session due to that we thought it would be easier to express the ideas if we were able to draw the game elements. A summary of the outcome from the brainwriting session can be seen below.

How can the group aspect be enhanced?

- Change the navigation bar and add a group icon
- If you press the create icon in the navigation bar you can create both quiz and groups

- Keep it in the profile view but make it clearer and put the creation of groups in focus on the profile

How can it be clearer of how to indicate the correct answer when creating a quiz?

- Add an explanatory text above the checkboxes that the user needs to select the right alternative
- The first input field is marked as the correct answer from the beginning which means that the user needs to insert the correct alternative in the first input field

How could the results from all the different attempts be visible?

- Show the results from the different attempts in the detailed view of statistics
- Use a drop-down to visualize all the attempts and the user can select the wanted attempt

Additionally, the phrasing throughout the application had to be clarified. A discussion was held about how we could change the labels to make it clearer what they referred to.

6.3.2.2 Braindrawing

We used braindrawing to generate solutions to the design challenge of how the monsters could be exchanged or improved. As in the first design iteration we used Crazy 8. A large amount of ideas were generated and to select the ones we liked the most we used the method called Four Categories Method. The categories: Most Delightful, Most Rational, Longshot and Darling were used and we voted individually on one idea per category. Thenceforth, the ideas that had been voted on were discussed and their advantages and disadvantages were noted. The definitive idea was the one called the Backpacker.

The backpacker idea was that the user travels around the world not only in the step-counter but also throughout the game. The user would collect points to fly from one country to another and the theme of each quiz would depend on which country the user is currently in. For example, if a user is in France the items to collect could, for example, be a french beret. We decided to move forward with this idea.

6.3.3 Prototype

To get a better understanding and visualise the new design we decided to proceed to the prototyping phase.

6.3.3.1 Sketching

The backpacker idea was sketched and merged with the new ideas from the brainwriting. The navigation bar was changed and a group icon was added. An explanatory text above the checkboxes was added to clarify that the user needs to select the

right alternative. A drop-down was used to visualize all the attempts and the user can select the wanted attempt. However, while sketching the backpacker idea we realised a couple of issues. We realised that most of the design had to be changed if continuing with the backpacker idea. This would require us to go back and test the functionality as a low fidelity prototype, due to the time limit of the project this would not be possible. Therefore we decided to go back to the define phase to rephrase the design challenge once again.

6.4 Iteration 3

This section presents the process and outcome of the third design iteration.

6.4.1 Define

A discussion was held with the supervisor and we received the advice to not focus on how we could exchange the monsters but rather focus on how to highlight the aspects and the game elements that received positive feedback. We looked back at our data from the testing and looked at what features that were unique for our design. We realised that the major unique functionality was the group aspect. That the user plays together and against groups. We decided to move forward and focus on the design challenge to focus on enhancing and improving the group aspect.

6.4.2 Ideate

When the design challenge had been rephrased in the define phase the ideation began.

6.4.2.1 Braindrawing

To generate ideas on how to improve and enhance the group aspect we used braindrawing. As in previous braindrawing sessions, we used the method Crazy 8. A summary of the generated ideas can be seen in the list below:

- See who else answered correctly when you answer correctly.
- Have an animation of the player and another player in the group if they both answered correctly, for example, that the players do a high five.
- That the group collects trophies when they play against other groups and these trophies can be seen in a trophy cabinet.
- Who wants to be a millionaire hints: call a friend, see what the group has answered and 50/50.
- To be able to both see how far the player itself has walked and how far the whole group have walked.
- Be able to collect items for the group.
- Be notified when all groups have played.
- Get positive feedback during the quiz about the groups' process.
- Be able to set a time when the group has a competition scheduled.

- If the player answers correctly they will be able to choose a package out of three packages which three other players in the group hold. The players collect the item that is inside the package.
- Find chests or packages in the game if you do not play with a group.
- Be able to get items that your friends have that you do not have.

6.4.3 Prototype

To highlight the group aspect and implement the ideas above meant that we could keep extensive parts of the low fidelity prototype and keep developing it into a high fidelity prototype and focus on developing the group aspect.

6.4.3.1 Sketching

We sketched the new design with these selected ideas:

- Sometime during the quiz the player can see who else answered correctly when you answer correctly.
- Have an animation of the player and another player in the group if they both answered correctly, for example, that the players do a high five.
- That the group collects trophies when they play against other groups and these trophies can be seen in a trophy cabinet.
- Be able to use a hint that is to see what the group has answered.
- To be able to both see how far the player itself has walked and how far the whole group have walked.
- If the player answers correctly they will be able to choose a package out of three packages which three other players in the group hold. The player collects the item that is inside the package.

We both sketched the ideas individually and the overall design of the application and quickly noticed that we had the same idea about how it would look like. We decided to start designing the high fidelity prototype.

6.4.3.2 Screen-based prototyping

Before we started prototyping we had to decide on a colour scheme. We knew from the interviews with the students that most of them liked Kahoot! and their colours. We compiled four different colour schemes, these can be seen in *Figure 6.6*.

We discussed the colour schemes and came to the conclusion that schemes 1 and 2 were a bit too similar to the colour scheme in Kahoot!. To gather quick feedback we asked friends and family to say which colour scheme they liked the most. Scheme 4 got preeminently most votes. Additionally, black text was most visible and distinct on the colours in colour scheme 4. The application will mostly be used outdoors and sometimes in sunlight and therefore it is of great importance that the text can be seen clearly. Based on this we chose colour scheme 4. Subsequently, the main

Figure 6.6: The color schemes.

colour had do be determined out of the four in the colour scheme. We tried the different colours in the explore-view and noticed that the pink colour was too bright and attracted too much attention. The yellow colour was too light when applied to small icons. However, both the green and blue colour worked well. The icons were clearly distinguished and the colours were not too bright. We discussed internally which we liked the most and the blue colour was a favourite. Based on this the blue colour became the main colour and the whole colour scheme was used to distinguish the different answer alternatives and the different parts of the statistics. Black text colour was used throughout the design besides on blue buttons where white text colour was used.

As with the low fidelity prototype, the high fidelity prototype was made in Figma. Before we started, the user interface components were created such as the avatars and icons which were created using Adobe Illustrator. The avatar is divided into five parts; hat, head, the upper part of the body, the lower part of the body and shoes. A selection of the avatar parts can be seen in *Figure 6.7*.

Due to that we were both beginners at Illustrator we spent quite some time illus-

Figure 6.7: Some parts of the avatar.

trating these avatars and we were too detailed. We realised that we had to focus on the parts of the design that we wanted to test to manage to finish the high fidelity prototype in time to have enough time to write and finish the report. However, the avatars were one part we really wanted to be illustrated well to be able to give the test participants a fair view of the final result.

The icons were, as stated, made in Illustrator. We had to design them ourselves to be able to manipulate the colour of them. For instance, we wanted to clearly highlight which destination the user is currently in with the main colour, which can be seen in *Figure 6.8*.

Three different trophies and packages were illustrated to be able to do a good high fidelity prototype. These can be seen in *Figure 6.9*. As with the avatars, we wanted to visualise these game elements as good as possible to give the test participants a fair view of the final result.

When all illustrations were made we began designing the high fidelity prototype. We proceeded from the low fidelity prototype as much as possible. Some views, for example, the create quiz process did not require much work. It was mostly about adding colours, designing the buttons and add the designed icons. However, other views such as the login view, the group view and the process when playing a quiz required more work, due to that they differed more from the low fidelity prototype. The group view and the process of playing a quiz were the main parts where we would highlight the group aspect.

During the prototype phase, new design choices were made. We realised that we had designed how it would look like when you use a hint but not how you chose to use it and if it would be visible that the player has used the hint in the statistics. We looked at other applications and quiz games that had a similar feature and took inspiration from them which led us to design a lifebuoy icon to indicate a hint. Additionally, in the detailed view of the statistics, there will be a lifebuoy icon next to the question which the lifebuoy was applied to, to indicate the use of hints to teachers.

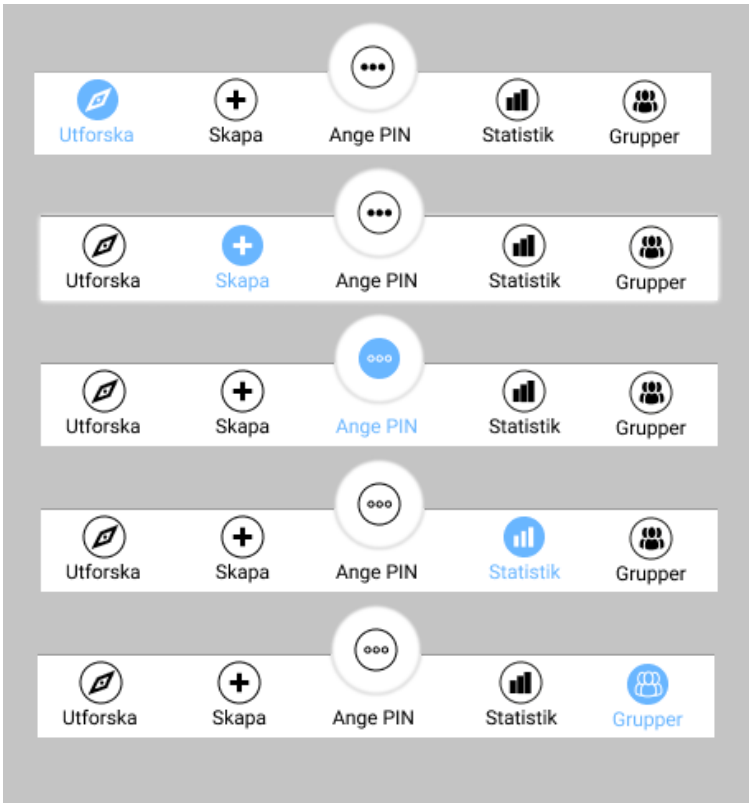

Figure 6.8: The navigation bar indicating which destination the user is currently in.

Based on the test results with the teachers it was requested to be able to see which questions the student had answered correctly in all of the attempts on the quiz. When we sketched the design we had chosen a drop-down to be able to choose what attempt you want to see statistics on but when we did the high fidelity prototype we realised that a drop-down does not provide a good overview of how many attempts were made, this made us rethink and decided to use buttons similar to radio buttons to indicate different attempts instead. It provided a better overview and easier to navigate between the attempts. We had an idea about being able to see the different attempts in the overview as well, for instance, identify the different attempts with a different kind of bars in the bar chart. However, due to the time limit of the project, this was not prioritised.

We discussed whether a group should get a trophy only when they come in first place in a competition or get trophies for first, second and third place. When we designed the trophy cabinet we realised that the cabinet could be quite empty if the group rarely compete against other groups or if they do not come in first place very often. This game element could then become unnecessary and lose its meaning. We wanted the trophy cabinet to be a motivation therefore we decided that first place, second place and third place will get a trophy that corresponds to their specific place. This means that the trophy cabinet will probably hold more trophies and it will be more encouraging for the group.

Figure 6.9: The illustrated trophies and packages.

6.4.4 Test

As with the first user testing, the second user testing had to be performed digitally due to the pandemic Covid-19. The tests were arranged in the same way as in the previous test phase explained in *Section 6.2.5*.

6.4.4.1 Test with students

The test in the first design iteration and the test in this phase was similar, both in the set-up as in a video accompanied by a questionnaire and in the way the video was compiled. This was to avoid the test participants to become biased and react differently depending on the context.

A new video was made describing the new interface with a new accompanying questionnaire. The questions focused on the game elements and which parts of the application the students liked or disliked. The game elements that were being tested can be seen in the list below.

- The avatar
- Meet other group members during a quiz
- Be able to choose a package that other group members hold
- The hint
- Competing against other groups
- The pedometer

- The trophies

The first question was if they were part of the last test phase because this would be very interesting for us to see and it could have an impact on the response. Some game elements were kept from the low fidelity prototype, for instance, the avatar. But it was still asked if they liked to choose an avatar and customize it to be able to see if the responses changed when the avatar had a higher fidelity. All questions regarding the game elements were asked in a similar way, the test participant had to pick on a likert scale from "Not good at all" to "Very good". There were some questions with answer alternatives such as the question regarding the pedometer, the participants had to choose if they rather see their own step counter or their own and the groups. The questionnaire had two finishing questions that were the same as in the previous questionnaire. One open-ended question where they had to write one thing they liked about the application and one thing they disliked and the last question was how they liked the application overall.

33 responses were received on the questionnaire. The responses can be seen in *Appendix I*. The main outcomes are summarized in the list below:

- **The avatar:** The avatar was appreciated, however, the look of them was still criticised.
- **Meet other group members during a quiz:** The response was that the students thought this was intermediate.
- **Be able to choose a package that other group members hold:** This game element was appreciated, which was seen mostly in the open-ended question. The students liked that you get a package but there was some feedback that they would rather collect points instead of items.
- **The hint:** Most of the students liked this feature but it was also as many that thought it was intermediate.
- **Competing against other groups:** This game element was very appreciated. They liked that classes could compete against each other but also that smaller groups can challenge each other.
- **The pedometer:** Most of the students liked seeing both their own step counter and the group's but the overall feedback of this aspect was a bit higher than intermediate.
- **The trophies:** The trophies were appreciated.

The last question that measured the overall satisfaction of the experience showed a somewhat more negative result than the same question in the last test phase. The responses also showed that the older students were more negative against the application than younger students.

6.4.4.2 Test with teachers

As in the previous test with teachers, usability testing was used and the test was held over Skype. Two female teachers participated, one at a time. One teacher was 46 years and taught students in middle school and tested the application in the

previous test. The other teacher was 55 years old and taught students in elementary school and had not tested the application before. They were asked to perform several tasks with the interface while sharing their screen. The participants were asked to think-aloud while doing the tasks. The tasks that were performed during the test are listed below.

- Create an account
- Create a group
- Create a quiz
- See profile
- See statistics
- Create a challenge

When all tasks had been performed the test participant was asked to give some overall feedback and comments. The outcome of each task is summarized below.

- **Create an account:** The process of creating an account was perceived as logical and no major problems were met. However, there were some problems understanding the process of creating the avatar. It was not clear what items that were currently indicated.
- **Create a group:** The "Create" icon in the navigation bar is still somewhat perceived as creating a group. But when pressing the "Create" icon and realising it was for the purpose of creating a quiz the next attempt was to press the "Groups" icons in the navigation bar. When the test participants had navigated to the group page the process of creating a group was easy to understand.
- **Create a quiz:** The process of creating a quiz was considered easy to understand but some questions were raised such as if upload an image and public/private were connected in some way. The summary page and that the user can invite both a group or using a pin were appreciated. Additionally, it was stated that it could be good with some guidelines when inserting how many steps the quiz would be.
- **See profile:** A logical process since the profile icon with the created avatar is clearly visible throughout the interface.
- **See statistics:** It was logical to find the statistics but it was not very intuitive that the bars in the bar chart were interactive. Additionally, it was not intuitive to find the detailed view of the statistics but when finding it, it was easy to understand how to see and read the statistics.
- **Create a challenge:** The process of creating a challenge was not intuitive. It was not easy to understand that a challenge was created from within the groups. However, it was logical to create a challenge when finding where to do it.

6.4.4.3 Test with adults without teaching experience

As previous test phase, usability testing was used with four adults without any teaching experience to gain more quantitative data about the usability of the appli-

cation. The same tasks were used. The test participants were of different genders, ages and with different technical backgrounds. One participant, as in the previous test phase, was non-Swedish speaking. A couple of participants had tested the first low fidelity prototype while some had not heard about the application before.

One of the test participants tested the application on an iPhone SE and later on an iPhone 11. The participant was given the first task on iPhone SE but she thought it was hard to read the text on the login screen. When one task was performed in the usability test, the participant switched to an iPhone 11 to continue the test. Therefore the readability on small screens could be an issue.

The outcome of each task is summarized below:

- **Create an account:** The process of creating an account was perceived as logical, but the button to randomise the avatar was not clearly discovered.
- **Create a group:** The "Create" icon in the navigation bar is still somewhat perceived as creating a group.
- **Create a quiz:** Even though the process of creating a quiz was considered easy to understand there was some vagueness about the meaning of the text indicating the number of symbols in the description box which was mistaken as the number of steps. Additionally, the GPS and step view would have benefited of some explaining text.
- **See profile:** A straight forward process.
- **See statistics:** It was considered logical besides the bar charts. It was not intuitive that the bars in the bar charts was interactive.
- **Create a challenge:** The process of creating a challenge was not perceived logical. The test administrator had to guide the test participants to complete the task.

7
Results

This chapter will present the result from the design process established from the research question: *"Which criteria should be considered when making an educational and engaging quiz as a physical activity for students in middle school?"*. The research question has been explored with a literature review but also throughout the design process of making the final prototype. In this chapter, the list of criteria that should be considered when making an educational and engaging quiz as a physical activity for students in middle school and the final prototype will be shown.

7.1 Criteria

Throughout the design process, the findings from the previous research have been combined with findings from the user study, designing and testing of the prototype. In this section, the list of criteria will be presented. In *Figure 7.1* a model of the criteria can be shown that visualise how the criteria are grouped for the two user groups, students and teachers.

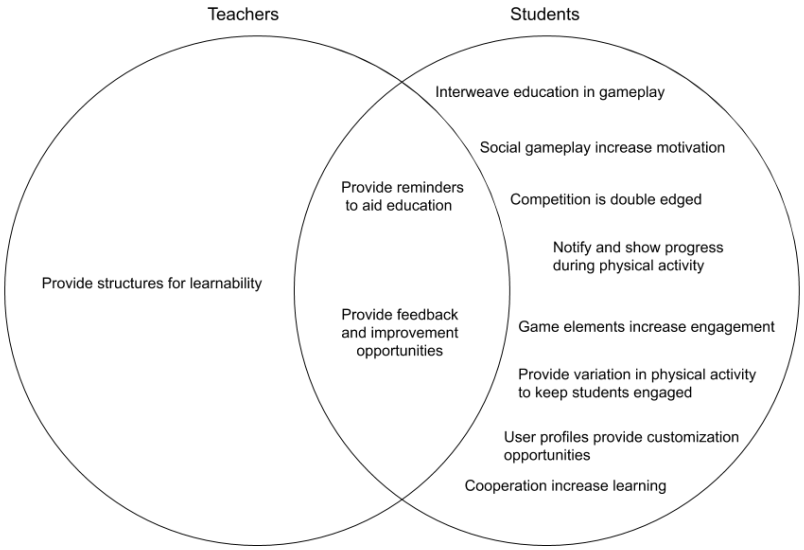

Figure 7.1: Model of the criteria for different user groups.

7.1.1 Interweave education in gameplay

When designing fun and educational games Bruckman suggests that the designer should make the learning inherently fun, put learning in context and learn things in a useful approach [46]. It is also suggested by research to interweave education in engaging gameplay when making educational gameplay that promotes health awareness [43]. In order to support learning it is important that gameplay is integrated in education. The game elements in the prototype, such as groups can challenge each other and that items can be found, are mostly connected to the process of playing a quiz, to interweave education in gameplay.

7.1.2 Social gameplay increases motivation

In previous research, it has been shown that social support for learning should be provided when making educational games[46]. In another study, it was seen that peer interactions give more active engagement by students [52]. The testing of the prototype showed positive feedback on the feature to be able to chat in a group and the overall group aspect.

In previous research, Suhonen mentioned that players both in online games and multiplayer games seem to be motivated to play by the social factor [43]. In the interviews with students, it was also frequently brought up by students that they like playing together with friends. Teams as a game element in learning contexts have also been tested with positive results by students [47]. Additionally, the testing showed positive feedback about playing in groups.

7.1.3 Notify and show progress during physical activity

A progress bar is a gameplay element that can improve an educational system by making it more enjoyable [47]. It was seen in additional research that progress, in general, can be used to gamify educational systems [50]. The progress of the user's walking is shown during a quiz in the prototype. The testing showed that students appreciated the step counter and the feature that they can see their progress of walking to a specific country.

Additionally, during observations and interviews with teachers, it was seen that students can easily lose focus while being outside. It was also stated that it would be preferable that the students do not look in their phones during the whole quiz when walking because other applications and chatting with friends could distract the students. During physical activity outside it is also important to be observant in case of traffic. Therefore, students should not be on their phones while doing physical activity but get notified when a question appears.

7.1.4 Competition is double-edged

Competition as a game element is enjoyed by students in educational games [47]. During interviews with students and observations it was shown that they tend to like

competition and that it motivates them. The positive feelings toward competitions were especially seen when observing a class when they played Kahoot!. However, during interviews with teachers, it was stated that competition can make some students feel pressured which was seen while shadowing students when they retrieved a test. Physical education that emphasises competition can also be negative since some students in these cases have encountered unsuccessful experiences which can make them dislike physical education [41]. Therefore when using competition in an educational and engaging user experience it is essential to not make students feel pressured.

In the prototype, as an attempt to avoid students feeling pressured, groups are competing against each other instead of student against student. The students' results are not visible for other students, only the average score of the group is shown. Testing showed that competition in this way was appreciated and students liked to compete group against group.

7.1.5 Game elements increase engagement

In previous research positive result has been seen regarding using game elements in learning contexts. These game elements were points, profile, teams, leader boards, progress bars and badges [47]. When testing the prototype the usage of the game element *items* was appreciated. In the test of the low fidelity prototype, the students were asked what they liked most, collecting points or to find items. The major part thought that finding items was funnier. This indicated that the game element item can be included in the list of game elements that increase engagement. The full list of game elements that have been designed and tested for in our prototype can be seen in the list below:

- Points
- Profile
- Leader boards
- Progress bars
- Badges
- Items
- Teams

Points mean that players collect points when answering correctly on a question during a quiz. Profile is that every player has a profile where they can for example manage their quizzes or change their avatar. Leader board is concerning the visualization of the winners' stand when a competition is finished. Progress bar means that the player can for instance see how far they have walked during a quiz. Badges are referring to the trophies that the groups can win. Items is the collection of diverse things, such as clothing pieces to the avatar. Teams is the belonging to a group.

7.1.6 Provide variation in physical activity to keep students engaged

In has been seen that physical activity that focuses on a variety of activities tend to have more positive feedback from students [41]. The findings concerning variety were particularly stated during the user research such as the interviews with teachers and students. The teachers clearly stated that variety is a requirement to be able to keep the students engaged. For example, different types of exercises during one class keeps the students more engaged. The students also said that variety in games and applications is very important otherwise they will become bored. In the final prototype, variation is included when playing quizzes since different events happen. For example, the user varies between walking and using the application to answer questions in the quiz. When testing the prototype, students mentioned that they thought it would be fun to walk while playing a quiz. To make an educational and engaging quiz as a physical activity some level of variety should be considered to keep the students engaged and to make them return to the application.

7.1.7 Cooperation increases learning

One way to use gamification to engage students in school in educational contexts is to utilize cooperation [50]. In the interviews with teachers and during observations in classes, it was noticed that cooperation was a big part of the education. The teachers also suggested that the students could cooperate when doing a quiz and that this, in some cases, could even increase the learning since students can learn from each other and to share knowledge is a learning experience. In the final prototype, students can get a hint from their classmates on one of the questions. The test result showed that students were positive against this feature. What differs cooperation and social gameplay is that cooperation is about sharing knowledge while social gameplay is the belonging to a group and being able to communicate within that group.

7.1.8 User profiles provide customization opportunities

Using profiles have been considered a positive game element in learning contexts [47]. During interviews with students and during the design process having an avatar that relates to your profile has received good feedback and was appreciated.

From previous research, it was shown that customization [50] is a criterion that can be used when making educational applications for students. It was seen in the testing of the prototype that students liked to make individual choices as for example creating and changing their avatar in their profile. Additionally, in the profile, the user can choose a country to walk to in the application which provides an individual choice and enables customization.

7.1.9 Provide feedback and improvement opportunities

The aspect of providing feedback and improvement opportunities was recognized from previous research. It has been seen that in order to combine promoting health awareness and engaging gameplay it would be beneficial to provide feedback and improvement [43]. Additionally, a study by Dicheva et al. mention that when designing an educational and engaging user experience for students it would be beneficial to incorporate feedback and improvement [50]. It was also particularly stated during interviews with teachers that they look at statistics of a test to understand what was hard and what was easy for the students. It was requested by a teacher to be able to see the progress of a student and see their results from the different attempts of playing a quiz. In the prototype, the creator of a quiz will be able to see statistics from all the players of that quiz and all different attempts. This means that a teacher can see the improvements and the process of the students, which received positive results in testing with teachers.

A couple of teachers also pointed out that the students prefer receiving their feedback directly. Is was also stated in the first test session that it should be possible for students to practice the same quiz several times to improve and learn continuously. In the prototype when the user has finalized a quiz the result will appear directly on the screen and it is possible to repeat the questions that the user answered incorrectly. Additionally, the user will be able to see a more detailed view of the questions and see what questions the user answered correctly and incorrectly. It is also possible to do a quiz several times to improve the result.

7.1.10 Provide reminders to aid education

Findings from observation and interviews showed that teachers do not have a lot of time left of their working hours since the majority go to classes or preparations. Therefore it is important to aid teachers in education. During observations and shadowing it was seen that students in middle school can easily forget about tests and need to be reminded. During the design process is was frequently brought up to use reminders to assist both teachers and students in education. For example, by reminding students about upcoming tests or to do their homework. In the prototype, it was designed that teachers could remind the students about an upcoming test by writing in the group and the testing showed that this feature was appreciated by the students. This feature is one way the application utilizes the method nudging, to remind the students to do their homework without forcing them.

7.1.11 Provide structures for learnability

Throughout the design process, the structure of an application has been seen important. When making educational gameplay that promotes health awareness for mobile games, the games should be easy to learn [43]. During the interviews with teachers, it was stated that applications have to be easy to learn since teachers have a different level of experience with mobile applications.

During testing of the low fidelity prototype with teachers it was shown that it was hard to find where to create a group due to that it was nested in the profile. In the final prototype, groups got their own tab in the navigation bar. In the usability testing, it was shown that this structure was easier to understand.

7.2 Prototype

During the process of this thesis, a prototype has been designed. Several design iterations have been performed to test the established criteria stated in *Section 7.1*. The prototype is a graphical user interface and exemplifies some of the criteria. The different parts of the design will be explained in this section.

7.2.1 Setting up an account

In *Figure 7.2* the process of setting up your account can be seen. As seen in the two screens to the left the user is able to log in or create an account if not having an account yet. There are three different options; create an account with the application itself, use Facebook or use Google. If the user already has an account the user presses the white button to log in and gets sent to the screen where an avatar can be created as seen to the right in *Figure 7.2*. The user can then press the blue arrows to browse through the options. The user selects a hat, a face, an upper body, a lower body and shoes to create an avatar. The user can also press the randomize button in the upper right corner to generate a random avatar. When finished, the user pressed the blue button to create its avatar, which will send the user to a view where the avatar is visualized.

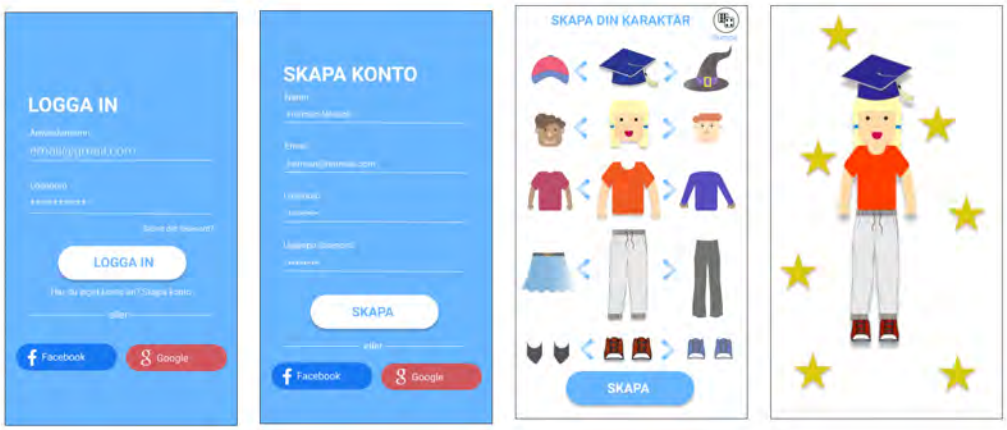

Figure 7.2: The screens for setting up an account.

7.2.2 Exploring possible actions

The explore page is the main view of the graphical user interface, seen in *Figure 7.3*. This is were the user first will be sent to after logging into the application. The user can search for quizzes, browse by category and scroll to find quizzes. All content in the application can be reached from here due to the criterion *provide structures for learnability*.

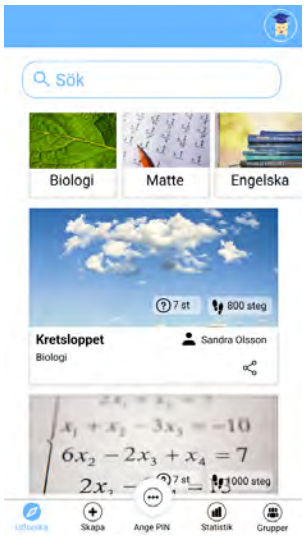

Figure 7.3: The screen for exploring possible actions.

7.2.3 Creating a quiz

In *Figure 7.4* the process of creating a quiz is visualized. The user enters the name of the quiz, a description, a category and indicates if the quiz will be private or public. Additionally, the user can upload an image that represents the quiz. When the user is satisfied with the quiz details the blue button is pressed and the user will get sent to the screen where the questions will be entered. The user will write the question, the answer alternatives and select which answer is correct by pressing the right checkbox. It is possible to select several answers that are correct and therefore checkboxes are used. There are two buttons, one that says "Finished with the quiz" and the other says "New question". The button that says "New question" will be disabled until all required fields are filled in, i.e. everything except the image. The user can create as many questions as desired. After entering all the questions the user presses the button that says "Finished with the quiz" and gets navigated to a screen where a summary of the quiz will be shown. The user gets a chance to review the quiz and change it if needed. When satisfied the user presses the button at the bottom of the screen to continue and will then choose if the quiz should be step-based or GPS-based. If step-based is chosen the user will input the desired number of steps. However, if GPS-based is chosen the user will draw a line on the map to determine the route of the quiz. The questions will be deployed with even distances in between them or the user choose where the questions will be placed. When finished the user presses the blue button and the quiz will be created and the

user will get sent to a confirmation screen. The user can from here decide how to share the quiz, either invite a group or share the quiz with a pin.

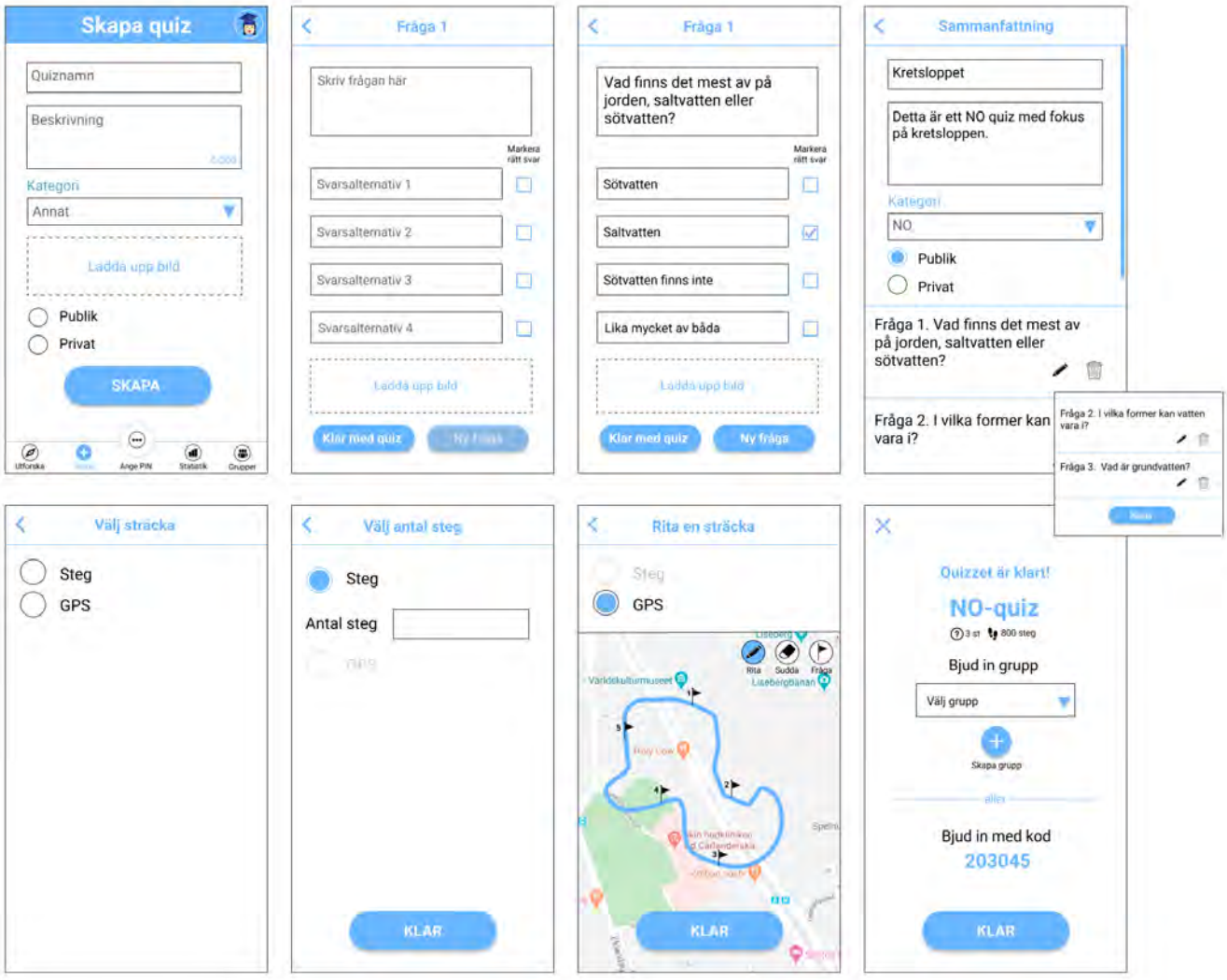

Figure 7.4: The screens for creating a quiz.

7.2.4 Playing a quiz

In *Figure 7.5* the screens for playing a quiz are visualized. In this case, the user will start a quiz by entering a pin. After entering the pin and pressed the button the user will get to the quiz view. This view includes the details of the quiz, such as how many questions it is and the total distance of the quiz. In this user scenario class 6B is playing against class 6A and 7B and the user can see its own avatar. Other users in the same group will be visible when they enter the quiz, which can be seen in the view furthers to the right in *Figure 7.5*. When ready the user presses the button to start the quiz.

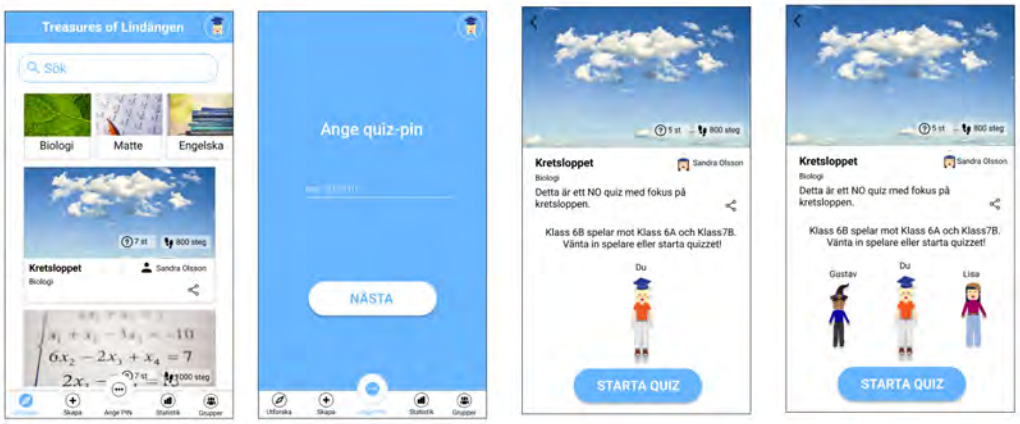

Figure 7.5: The screens for starting a quiz with a pin.

In *Figure 7.6* selected screens from the quiz can be seen. The user can follow its progress in the quiz in the progress bar which is an example of the criterion *notify and show progress during physical activity*. The bar will gradually be filled in as the user walks. It is communicated how far it is until the next question, how far the user has walked in total and how many questions have been answered. When the user has walked, in this case, 50 steps the first question will appear. The four answer alternatives will be visible and the user will select one of them. During the quiz, different events will happen to provide variety for the user. This exemplifies the criteria *interweave education in gameplay* and *provide variation in physical activity to keeps students engaged*. One event is that if the user answered correctly another user in the group will appear who also answered correctly on that question. An animation is displayed where the two users do a high five. Another event is that the user gets the opportunity to pick a package from another user in the group if the question is answered correctly. In this user scenario, the user found a crown that will be collected. The last event that can happen is that the user can get a hint by pressing the icon of a lifebuoy, which is an example of the criterion *cooperation increase learning*. The hint is to know the average answer of the group on the particular question. The hint can only be used once during a quiz, which means that the lifebuoy icon will be disabled when used.

When the quiz is finished the result will be visible directly. These screens can be seen in *Figure 7.7*. If the quiz was played as a competition a winners' stand will visualise the result. Only the average score of the group is shown due to the criterion *competition is double-edged*. A more detailed view of the result can be seen where the correct questions are indicated with a green colour and the incorrect are indicated with a red colour. If a quiz is not played as a competition, the view to the left will be seen. The user can still see a more detailed view of the result but also repeat the questions that were answered incorrectly.

Figure 7.6: The screens for playing a quiz.

7.2.5 Viewing statistics

In *Figure 7.8* the screens for viewing statistics is shown which is an example of the criterion *provide feedback and improvement opportunities*. In this view the user can see two different lists; their latest played quizzes and their game rounds. The latest played quizzes show information about the name of the quiz, if it is step-based or GPS, the number of questions on the quiz, the best result and how many times the user has played the quiz. The game rounds show additional information about how many users that have played the quiz, the name of the group or the pin code used and the average result of the players.

The user presses the desired quiz to see more statistics. If it was a game round the user gets to the screens shown to the right in the first row in *Figure 7.8*. The user can share the statistics. The first view is an overview of the statistics where the user can see a bar chart and a circle graph. The bar chart shows statistics about how many users answered right on which question. The circle graph shows the division

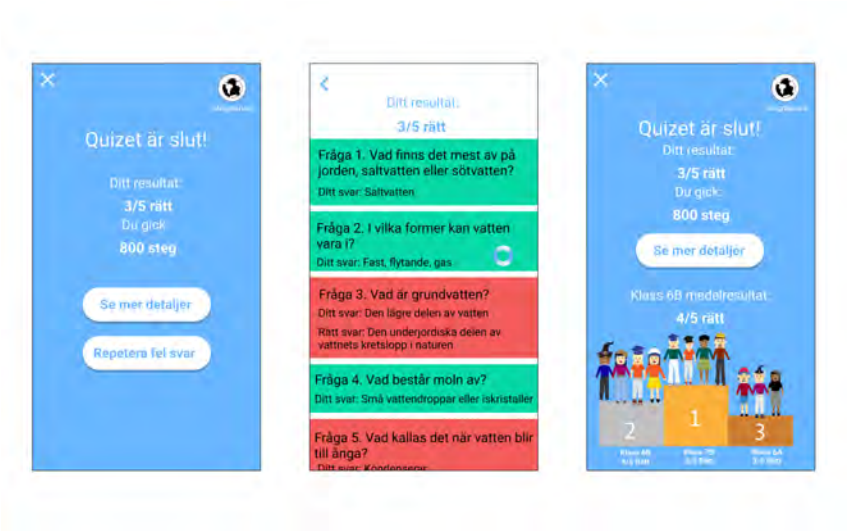

Figure 7.7: The screens for viewing the result of a quiz.

of the number of correct answers. Both charts are interactive and the user will get more information when interacting with the charts.

If the user presses the tab "Detailed" it gets to a more detailed view of the statistics. In the more detailed view, a list of cards with the players can be seen. In the list, the user can see the result of the user, how many times it has played the quiz and if the hint was used. If a user presses a card the card will expand and show even more details about that specific player. The user can see which questions were answered correctly and incorrectly in all of the attempts. The question in which the user used a hint has the lifebuoy icon next to it. The user can navigate between the attempts by pressing the circles that hold a number.

7.2.6 Creating a group

The user can create a group within the application which can be seen in *Figure 7.9*. If the user does not have any groups the screen will look like the one in the upper left corner. To create a new group the user will press the blue button with a plus and gets sent to the create group view. A group name should be specified and members can be added by searching on their names. When all group members are selected the user presses the button to create the group and gets sent to a confirmation page. This page will provide an overview of the group.

7.2.7 Managing groups

If a user receives a group invite it will be shown as a red notification in the navigation bar as seen in the first view in *Figure 7.10*. When the user enters the group view the user sees the list of groups it is a member in and the group requests. If the user presses any of the groups it gets to that group's page. In this use case, the user presses the group called "Class 6B". This user is the creator of that group which means it can edit the group. The members can chat which is an example

Figure 7.8: The screens for viewing the statistics.

of the criteria *social gameplay increases motivation* and *provide reminders to aid education*. The user can also see the number of members and the quizzes available. The user can also add quizzes to a group. When the user presses the button "add quiz" a drop-down menu will appear. The user marks the quizzes that it wants to add. If a quiz is added to a group, the group can challenge another group on that quiz. The user will press the blue "challenge" button which will lead them to the challenge view. The user will then search for the group or groups that it wants to compete against in the chosen quiz. In the group view, there is an icon in the upper right corner that symbolises the trophy cabinet which can be seen in the bottom left corner in *Figure 7.10*. The trophies are either gold, silver or bronze and are won in the competitions against other groups. The trophies are an example of the game element badges which exemplifies the criterion *game elements increase engagement*.

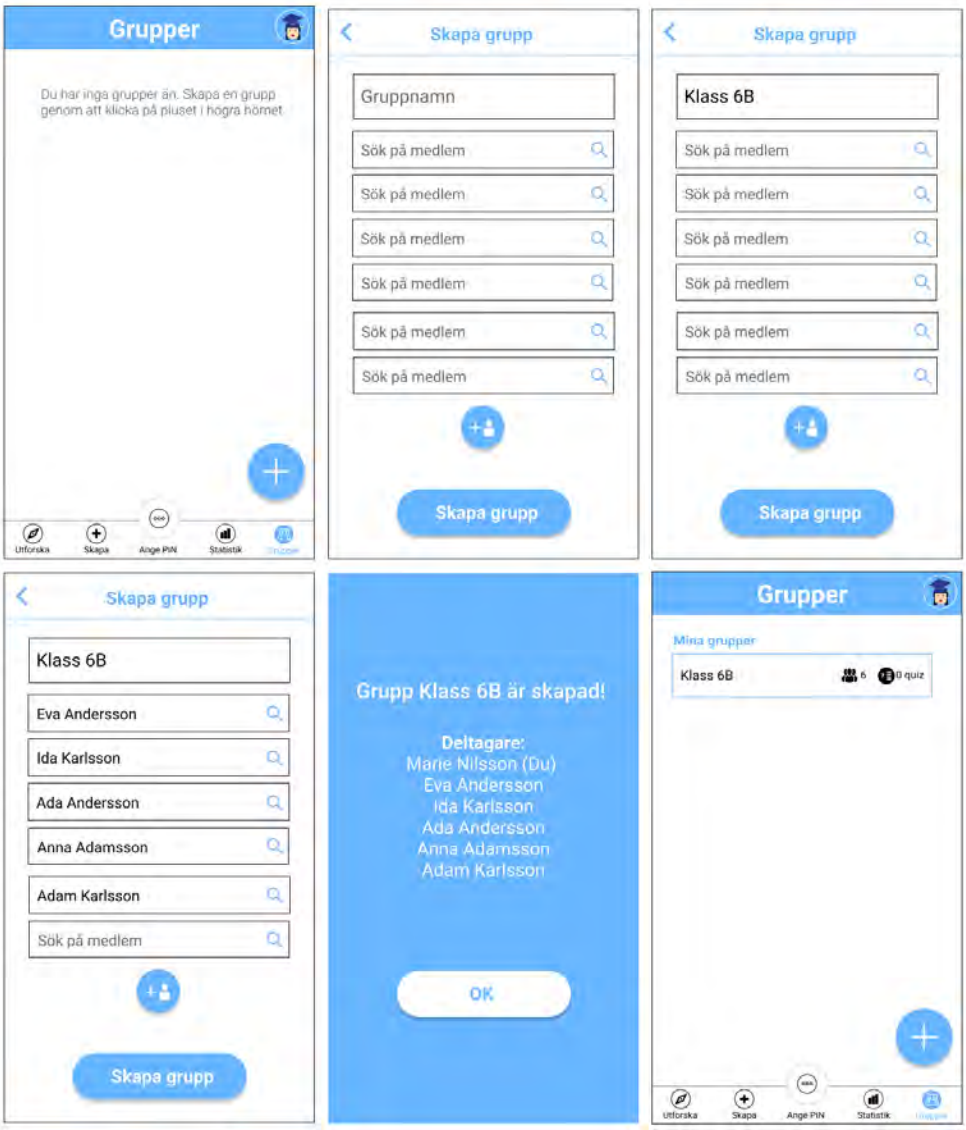

Figure 7.9: The screens for creating a group.

7.2.8 Viewing profile

In *Figure 7.11* the screens relating to the profile can be seen. In the profile view, the user can see their avatar and their name. The user can see the last played quiz, to easily be able to play them again. The user can also see their own created quizzes. The quizzes that the user has created can be edited and deleted. If the user presses the globe icon the user will arrive to the step counter view. The first time the user enters the step counter, the user can choose a destination to walk to in the game. The user can spin and zoom on the globe and will see the names of different countries. When the user presses the "choose" button a map will visualize the progress of the walking to the destination, both the user and the user's group's total distance will be shown. If the user presses the backpack icon the user can customize its avatar which exemplifies the criterion *user profiles provide customization opportunities*. If the user has collected an item during a quiz the backpack icon has a star on it.

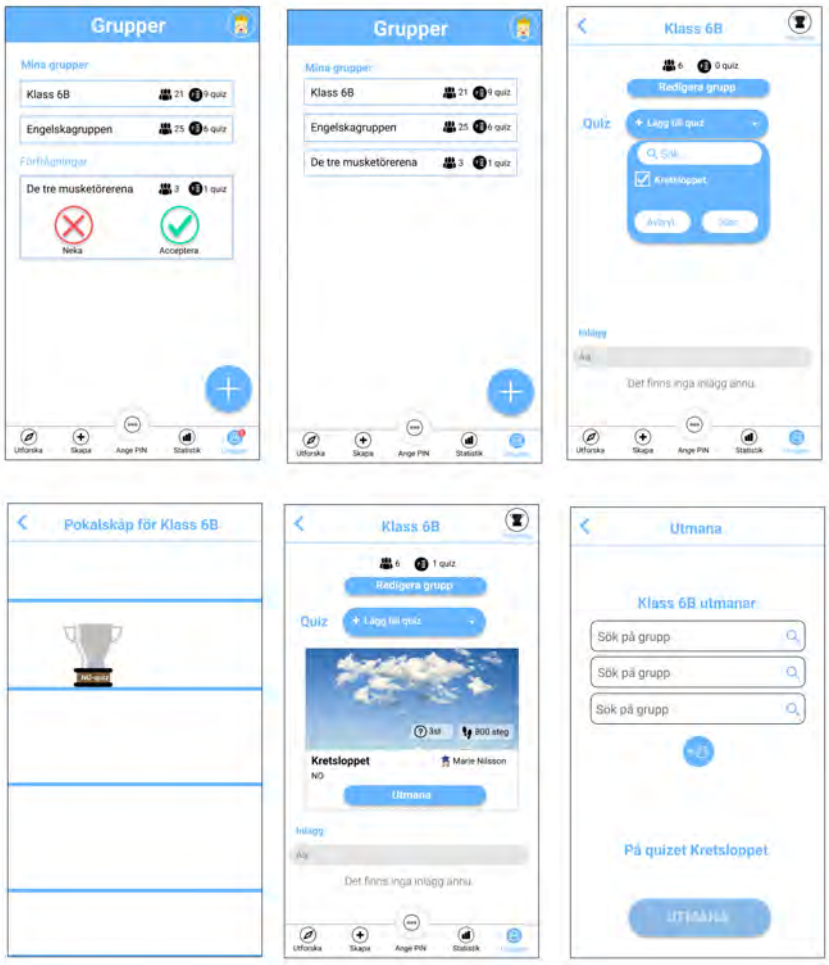

Figure 7.10: The screens for managing groups.

When changing the avatar, the arrow indicates with a star where the new item is. If customizing the avatar, the profile page will be updated with the new avatar.

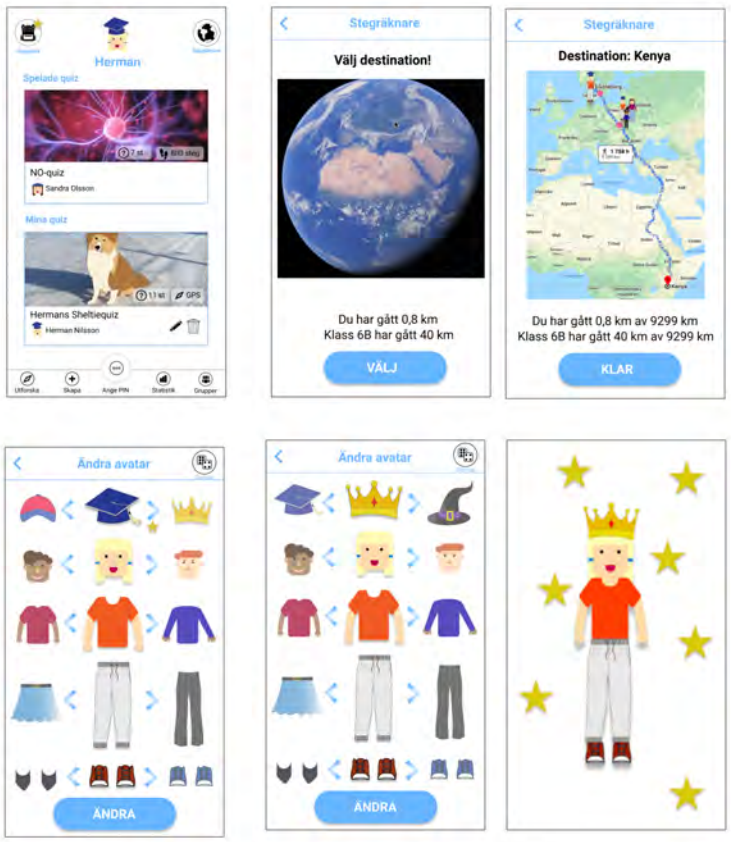

Figure 7.11: The screens for viewing the profile.

8

Discussion

This chapter discusses the result and the process of the thesis. Additionally, a discussion will be held around the ethical aspects and potential future work.

8.1 Result discussion

The design process resulted in a set of criteria that should be considered when making an educational and engaging quiz as a physical activity for students in middle school. The criteria were based on previous research, insights from user research and test results. The list of criteria stated in *Section 7.1* is the result of this thesis. It also resulted in a high-fidelity prototype exemplifying some of the criteria.

During the design process, a change of direction was made where the design focus changed. The design team realized that the characteristic feature of the prototype was the group aspect. It was seen during the testing of the low-fidelity prototype that students appreciated competing in groups against other groups and that it is possible to chat in the groups. The criteria need to be understood in their context. They need to be used with this mind, that the criteria have been formulated with the group aspect as a focus. If this change of direction had not been made the result could have been different, both the criteria and the final prototype.

Testing of the prototype has been conducted in two iterations to be able to formulate the resulting criteria. To verify the reliability of the criteria more testing would need to be conducted. Both more testing of the final prototype and testing the criteria when applied to other designs.

The criterion *provide structures for learnability* was not tested on students and is therefore not a criterion for students in the result. But in general, learnability is relevant for students as well. For example, it was seen in previous research that mobile games that promotes health awareness should be easy to learn [43].

8.1.1 Consideration of alternative gaming elements

There were several criteria that were found in previous research but that the design team did not find support to in the design process. For instance, Dicheva et al.[50] studied what game elements that have been utilized in gamifying educational systems. They found several educational gamification design principles, where one of

them was quests, for example searching for a treasure on a map. During observations and interviews with students, quests were never brought up, neither were games that were quests oriented. Students tended to like games that focused on competitions, action and customization. Therefore the design team did not continue exploring this criterion. Additionally, Bruckman suggested that when designing fun and educational games the designer should, amongst others, use open-ended tasks[46]. However, since the application is a quiz application that is going to be used while doing physical activity the design team decided that to use open-ended tasks would not be beneficial. A discussion was held whether it would be able to use open-ended questions in the quizzes but it was concluded that it would require more process work for the teachers and it would not be suitable in a quiz application where the users are doing physical activity.

There were also potential criteria that were brought up in the user research which were also designed and tested in the low fidelity prototype but did not receive positive results. They were therefore removed from the final prototype. Examples of these criteria are action and storytelling. It was seen in the interviews with students that they liked games with action. Storytelling is a good design principle when gamifying educational systems [50]. However, since it was a low-fidelity prototype the criterion action was hard to visualize and the design was pictures of monsters that talked to the student. These pictures received negative feedback, for instance, that they were ugly and weird. If a high fidelity prototype, that visualized action better would have been made, it could have received a better test result. With further research and in-depth testing it can be a potential criterion.

8.1.2 Limitations of the testing

One issue with the testing that can make the result less valid is that it was conducted without doing physical activity. The design team tried including the element of walking by showing in the video how the user walked outside. But since one big part of the research question is physical activity, testing without doing physical activity decreases the validity of the result. Therefore further testing has to be conducted with students while doing physical activity.

Another issue with the testing is that playability was not tested. In *Section 4.6.2.1* some playability heuristics designed for mobile games were mentioned [16]. Some of the playability heuristics have been taken into account and tested with good results. For example, the trophy's won as a reward was enjoyed by students and also the items that could be found in the quizzes which can be translated to the heuristic: the players are rewarded and rewards are meaningful. But some heuristics are not tested, for example, the heuristics: the game and play sessions can be started quickly. Since the user does not interact with the prototype, this heuristics could not be tested.

One drawback when conducting usability testing with teachers was that Figma shows hints on the prototype where the interactions take place. Some of the test partic-

ipants mentioned that they did not have to think since Figma showed hints where to press. To avoid this problem the prototype could have had more necessary interactions per view. Another solution could be using another tool for testing the prototypes.

The result of testing with students was more negative in general towards the second prototype than the first one. This could be due to that the second prototype had worse functionality, but could also be due to the similarity in testing. To verify this test result, less similar tests could be used or different schools or students could test the prototype.

8.1.3 Age impact on result

Although one of the user groups is middle school students in grades four to six a trend was seen that the younger students preferred the application more than the older students. This might be due to different attitudes in classes but might also be because the design works better for younger students. It has been discussed that the low fidelity prototype could work for even younger students than the ones in the user group. One student which was in second grade tested the low fidelity prototype and that test gave positive result. More testing and research have to be conducted in order to validate this hypothesis. Therefore an future directive is to research if the result work for younger students.

8.2 Process discussion

This section discusses some methods used during the design process and which impacts changes of the plan had on the result.

8.2.1 The usage of Personas

In the design process, personas were used as a way to get a better understanding of the data gathered from user research and to personify the themes and patterns identified. They helped the design team to summarize the data gathered and get a better understanding of the users' needs and the type of users that would use the application. However, the personas were mostly used in the beginning of the design process and did not have a significant impact later on in the design process. They could have been utilized more, as a reminder of the users and their needs when the design challenges had to be redefined. They could also be used more throughout the design process to establish a good communication about the users. But the time spent on defining the personas was worth it because it was helpful when processing the data gathered and provided a good foundation when moving on to the ideate phase.

8.2.2 Changes of plan due to Covid-19

The main reason for changes in the planning was because the design team started working remotely in the middle of the design process, due to Covid-19. As seen in *Section 5.2.5* the plan was to test the low-fidelity prototype with usability testing and a customer satisfaction score survey using emojis in the schools with students. It was also planned that the teachers would test the prototype at the schools to see if the application is helpful when making quizzes and showing statistics. Since the work was done remotely testing could not be performed in schools. Usability testing was conducted with teachers over screen-sharing on Skype. This test was somewhat similar to the planned test since the design team could still see the participant's facial expressions, see the interactions with the interface and the participant were still asked to use the technique think-aloud.

The usability test planned with students of the first low fidelity prototype was harder to replicate remotely. Instead of the students testing the interactive prototype, a video showed the possible interactions within the interface with an accompanying questionnaire. In the video there was footage of the user walking outside, to get the feeling of the important aspect of physical activity. The second test for students and teachers of the final prototype was decided to be identical to the first test.

8.2.3 Pros and cons with testing remote

There were some drawbacks when testing remotely with teachers. The main drawback was that only two teachers tested each of the prototypes. If the testing would be conducted at the schools, it would probably be easier to get more test participants that were teachers. This would lead to more data and the test with adults without teaching experience could be excluded.

Regarding the testing with students, there were both positive and negative outcomes with testing with video and a questionnaire remote. One positive outcome was that more students could test the prototype. The plan was to only have a usability test with around 5 students but with the test being held remotely 38 students tested the low-fidelity prototype. Another positive aspect of testing remotely was that the students could perhaps be more honest, since it may be easier to write negative feedback online than saying it in person.

Negative aspects of testing remote were that the usability is hard to measure since the students do not interact with the prototype. Students may also think it was time-consuming to answer a questionnaire and did not take it seriously. In the test, it was only one open-ended question that gathered qualitative data, this was seen useful to support the quantitative data. More open-ended questions would have been beneficial to get a better understanding of the data. More research about conducting usability test online would be necessary if redoing the project remotely.

8.3 Generalizability

The testing would have to be broader to provide more support to that the result of the application works for all middle school students in Sweden. Still, it is argued that since testing was performed with students from one school in the countryside, one school in a wealthy suburb and one school in a socioeconomically challenged area it provides more support to that the application and result can work in general for all middle schools in Sweden.

Because of the limited usability test with teachers, it is more difficult to argue that the result is general for all teachers in Sweden. Only two teachers tested each of the prototypes and one of the teachers tested both prototypes. All teachers that tested the prototypes were women and no one was older than 55 years old. Two of the test participants were also teachers for elementary school and not middle school. Further testing would have to be conducted with more middle school teachers and with teachers who are older than 55 to know the generalizability for all middle school teachers in Sweden. It could also be useful to test with both male and female teachers, however, the test result from adults without teaching experience showed no differences regarding gender. The differences were seen related to age and technical experience.

8.4 Ethical issues

As mentioned in *Section 5.4* there are some ethical issues, both positive and negative, that could potentially arise in the project. In this section, issues that were taken into consideration will be discussed.

An ethical issue could be the language of the application. It might be a challenge that some students do not have Swedish as their main language and they might not understand the application and the quizzes which can evoke feelings of being excluded and lead to social exclusion. This may also impact the learning curve due to that students with Swedish as their main language might learn more while using the application. When testing the prototype with adults without teaching experience, a test participant did not understand Swedish. The test participant understood the application nearly as good as the Swedish speaking test participants. One test result does not prove if all users without Swedish as their main language would understand the application. But it can imply that the design does not have to be changed completely, in order to make it understandable for users without Swedish as the main language.

This master thesis only designed a prototype, so the issue regarding that all students in a class may not have the same type of smartphone, that could evoke feelings of being excluded, was not in the scope of this project. Still, in order to make the usage of the application as broad as possible, the final prototype was designed with-

out a specific platform in mind. It was brought up during interviews that teachers like to create quizzes on the desktop and not on the mobile or the iPad. Teachers also mentioned during interviews that their students would be allowed to use their mobile phones during quizzes, even if it is prohibited to use mobile phones in their school. Therefore it was less important to consider designing for iPad throughout the design process.

Another ethical issue was regarding cheating on quizzes which was addressed during interviews with teachers. It was brought up that cooperation could be beneficial while playing quizzes since it can be a learning experience itself. It was suggested to make quizzes available for playing in groups of two or more players. However, it is still ethically wrong to cheat during tests, for example using google or calculator to answer the questions. Since the students would not learn and the teachers would get a false understanding of their students' knowledge. It was therefore discussed with a teacher to restrict the use of other applications while using this application for tests.

Finally, with GPS-based quizzes, it is hard to know if the user is walking or using a vehicle to get to the location. Using a vehicle is another sort of cheating due to that the purpose of the application is that the users should be walking, while doing a quiz. This would lead to the user not doing physical activity while using the application. To eliminate this, one solution that was not designed and tested for in the prototype, is to track the speed of the user to determine whether they are using a vehicle or not.

8.5 Future work

A couple of improvements of the criteria and the prototype should be considered. First, more extensive testing needs to be performed. The criteria need a more thorough testing in order to validate them and the design of the application needs more testing. The concept itself requires a more in-depth test, such as performing usability testing with both teachers and students in person. A prototype that enhances the intended experience would be needed to be able to test the design in its real context, such as at a schoolyard while doing physical activity.

Secondly, some additional user research with the user groups could be conducted to verify the outcome of the user research made in this thesis. To get more in-depth user research a focus group can be used, one with teachers and one with students.

The implementation of the application was not in the scope of this thesis and can therefore be seen as future work. It is suggested by the design team to implement the application both for iOS and Android since it was seen during observations that students had both Android and iOS devices. It could also be considered to design and implement a desktop version for creating quizzes and managing the statistics in order to make those processes easier and quicker.

To eliminate some of the ethical issues, the application could be available in different

languages and give the opportunity to restrict the use of other applications when doing a test to prevent cheating. Additionally, the application could track the speed of the user in order to recognize if the user uses a vehicle to move instead of walking.

9
Conclusion

The work in this thesis has been to research and designing a prototype to answer the research question:

"Which criteria should be considered when making an educational and engaging quiz as a physical activity for students in middle school?".

Based on previous research, user research including interviews and observations with student and teacher a low fidelity prototype was designed and tested. Based on the test results a final prototype was designed and tested shown in *Section 7.2*. Based on the design process a set of criteria answering the research question was formulated which is listed below.

- Interweave education in gameplay
- Social gameplay increases motivation
- Notify and show progress during physical activity
- Competition is double-edged
- Game elements increase engagement
- Provide variation in physical activity to keep the students engaged
- Cooperation increases learning
- User profiles provide customization opportunities
- Provide feedback and improvement opportunities
- Provide reminders to aid education
- Provide structures for learnability

There are probably more criteria that can be considered when making an educational and engaging quiz as a physical activity for students in middle school but these have not been investigated in this thesis. More extensive testing and user research have to be performed in order to validate the criteria. Taking this into consideration, the design team believes that the criteria can be used as a recommendation for other designers when making an educational and engaging quiz as a physical activity for students in middle school.

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A

Timetable for thesis proposal

The timetable made for the thesis proposal of the master thesis.

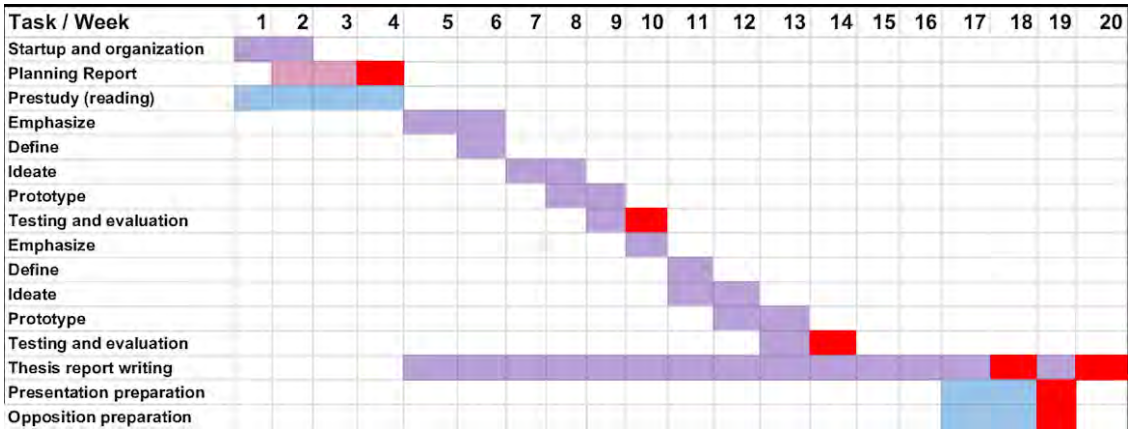


Figure A.1: Timetable for this master thesis for thesis proposal.

B

Timetable for planning report

The timetable made for the planning report of the master thesis.

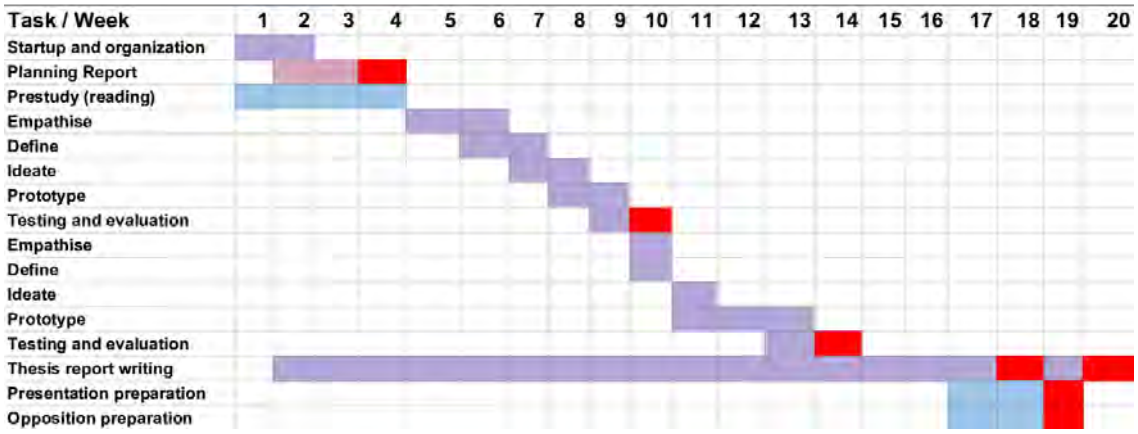


Figure B.1: Timetable for planning report for this master thesis.

C

Parents signature for interviews with students

A signature was needed by a parent in order to interview children in school. Therefore a signature form was made and handed out to teacher that gave them to the students. The form can be seen below.

Användarstudie för hälsofrämjande quizapplikation för skolan

Vi är två tjejer på Chalmers Tekniska Högskola som gör vårt examensarbete inom Interaktionsdesign. Vi ska tillsammans med företaget Semcon utveckla designen på en mobil app. Arbetet syftar till att förstå om och hur frågespel kan stimulera mera fysisk aktivitet i skolmiljö.

För detta behöver vi göra användarstudier och ska därför till er skola för intervjuer med lärare och frivilliga elever. Observationer kommer ske och planen är att ha två tester av designen senare i vår.

All data kommer pseudonymiseras och sparas men inte användas till något annat än examensarbetet. De personuppgifter som samlas in skriftligt under intervju är: ålder, kön, namn, åsikter och tankar om spelaktiviteter i och utanför skolan. Personuppgifter kommer inte att publiceras.

Under testning hade vi velat dokumentera genom att ta bilder för att användas i examensrapporten. Bilderna kommer anonymiseras och ansikten på någon elev kommer inte synas.

Ort och Datum _____ Föräldrers namn _____

Elevens namn _____ Föräldrers signatur _____

D

Interview questions aimed for teachers

The questions from the interview with teachers in the first empathise phase is presented in this appendix. Since the teachers was Swedish, the interview and questions also is in Swedish. Follow up questions depended on the answer and will not be addressed in this appendix.

Q1: Skulle du vilja berätta lite om dig själv och din roll på skolan?

Q2: Hur ser processen ut för att göra och ge ut ett prov, läxför, quiz idag?

Q3: Använder ni digital verktyg för prov/läxor/quiz idag?

Q4: Hur motiverar ni elever att göra läxan?

Q5: Efter ett quiz vad vill ni ha för statistik?

Q6: Vad är viktigt för barnet att få för statistisk? Feedback?

Q7: Vad ser ni för användingsområden med en sån här app?

Q8: Hur ser ni på sammarbete i quizzes?

Q9: Hur kan vi motarbeta fusk i appen?

Q10: Har ni redan sätt där ni försöker få in mer fysisk aktivitet i skolan?

Q11: Vilken typ av bedrift belönar ni idag och varför?

Q12: Hur motivernar ni elever som det inte gick bra för proven? Hur går ni till väga?

Q13: Hade ni föredragit en självständig quizapp eller mer ett spel med story där quiz på något sätt kommer in?

E

Interview questions aimed for students

The questions from the interview with students in the first empathise phase is presented in this appendix. Since the students was Swedish, the interview and questions also is in Swedish. Follow up questions depended on the answer and will not be addressed in this appendix.

Q1: Vad heter du och hur gammal är du?

Q2: Spelar du några spel?

Q3: Gör du någon idrott/sport på fritiden?

Q4: Gillar du idrotten i skolan?

Q5: Spelar ni några spel i skolan?

Q6: Har du något favoritämne i skolan?

Q7: Hur gör du dina läxor?

F

Personas

The personas made during the design process.

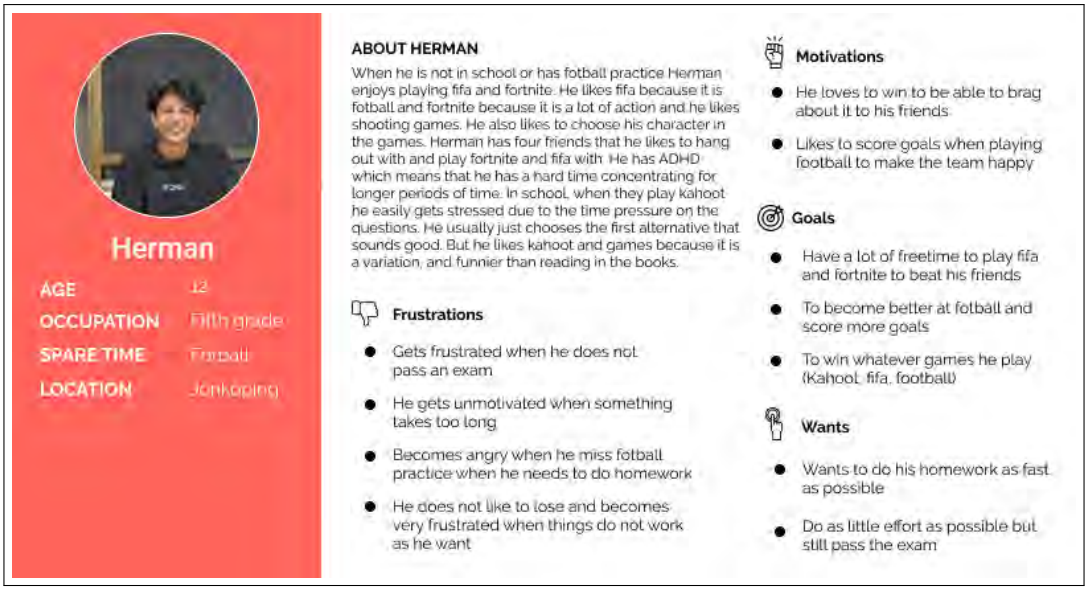


Figure F.1: The persona called Herman.

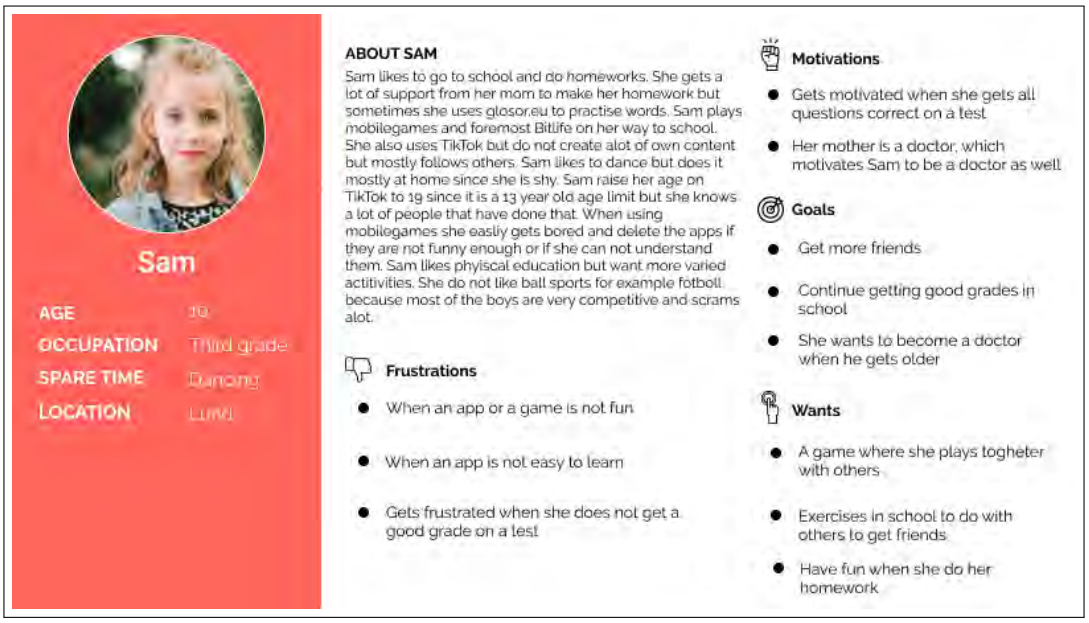


Figure F.2: The persona called Sam.

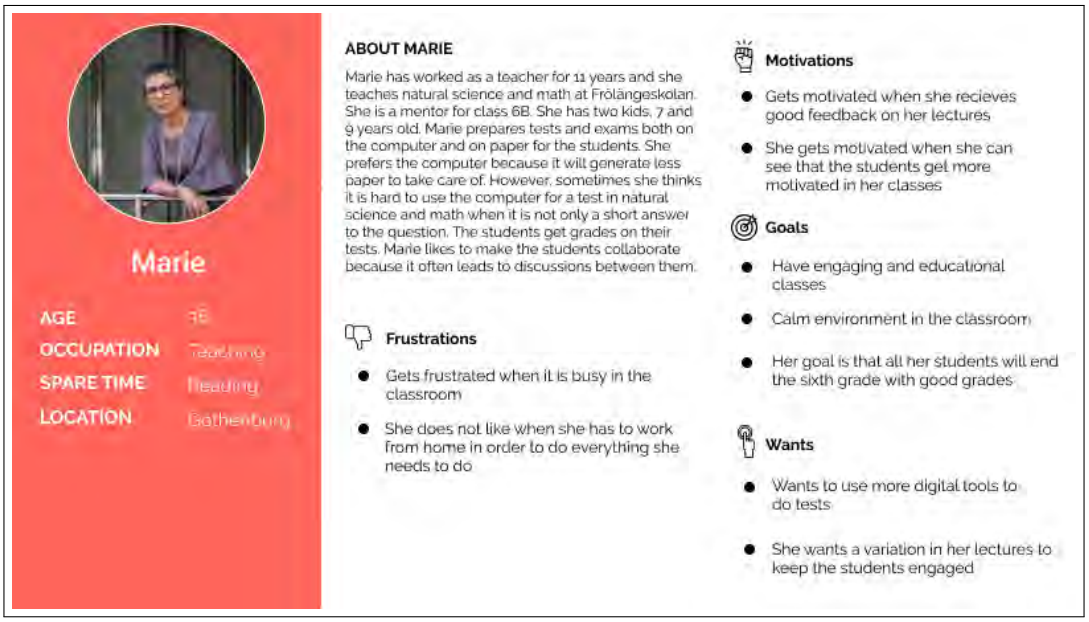


Figure F.3: The persona called Marie.

G

User Journey Map

The user journey maps made in the design process.

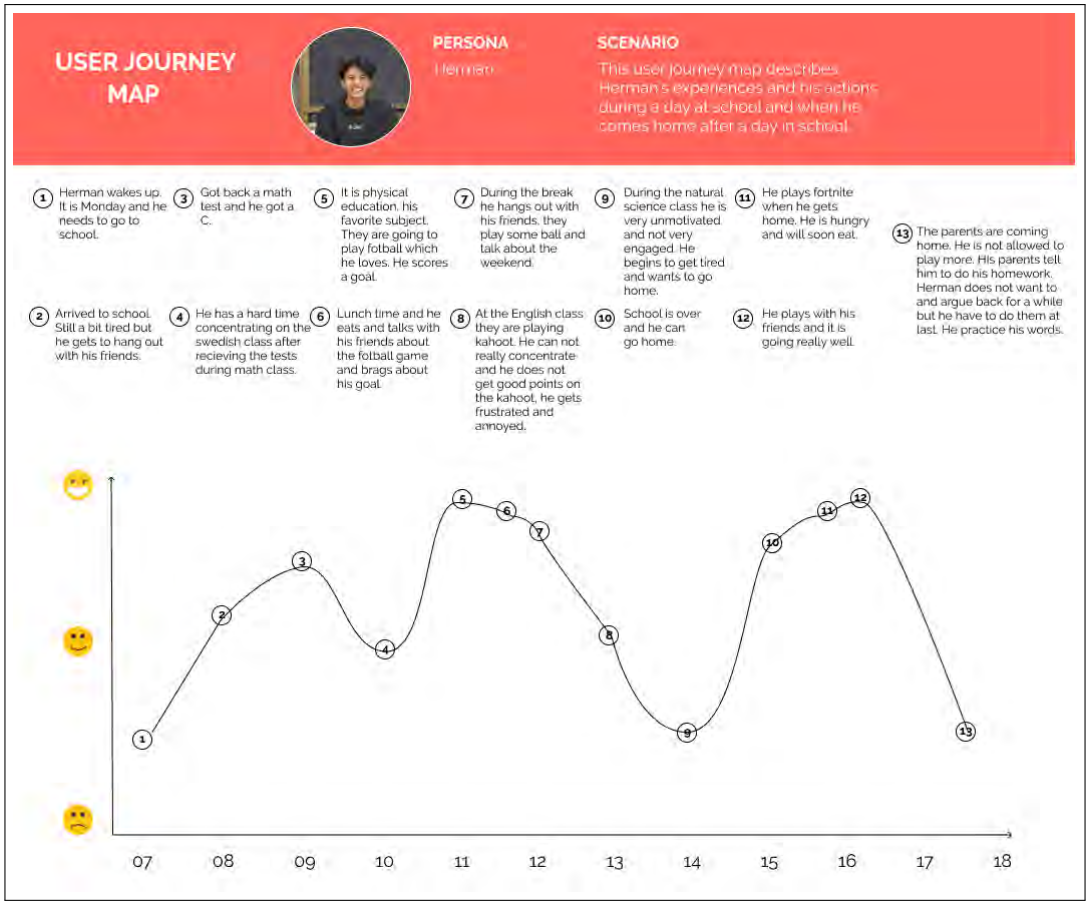


Figure G.1: A user journey map based on the persona called Herman.

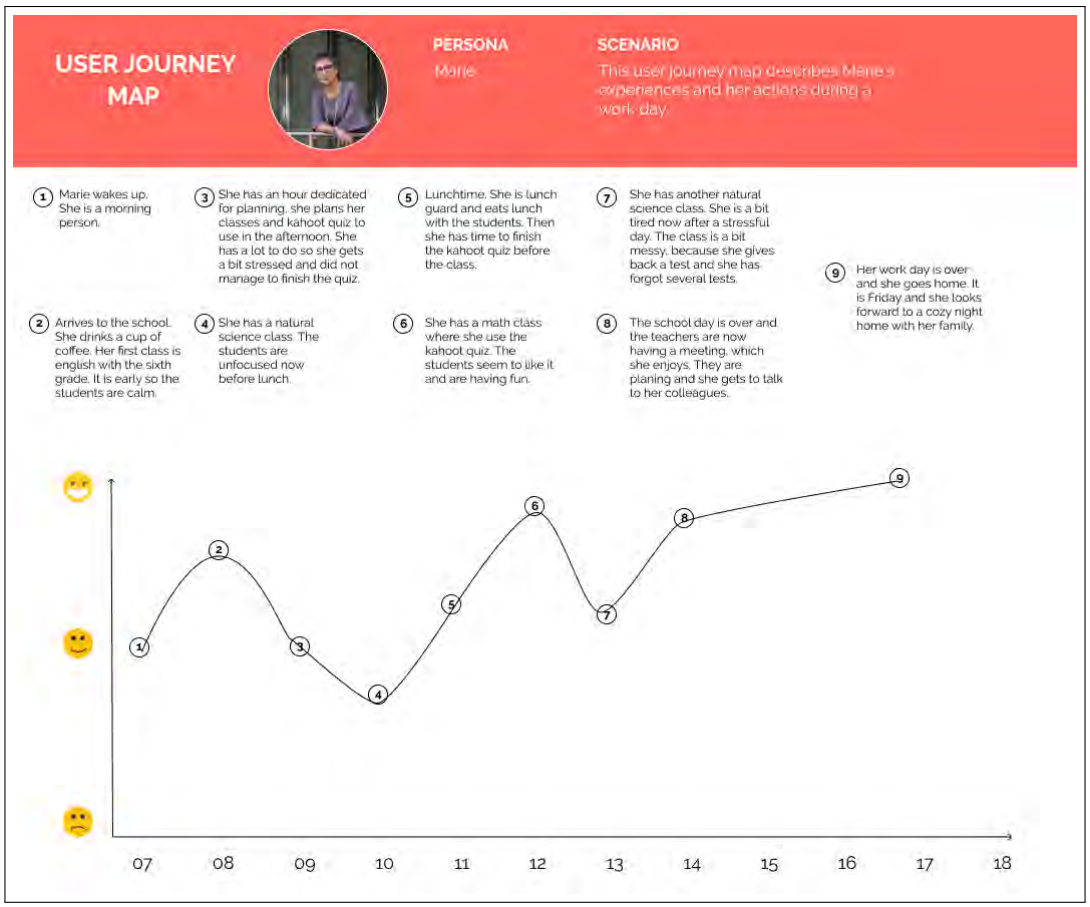


Figure G.2: A user journey map based on the persona called Marie.

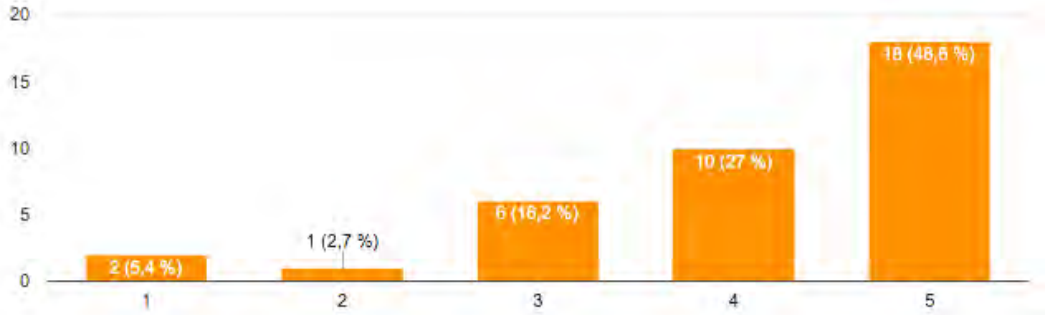
H

The result from the testing of the low fidelity prototype with students

The result and questions from the testing of the low fidelity prototype with students.

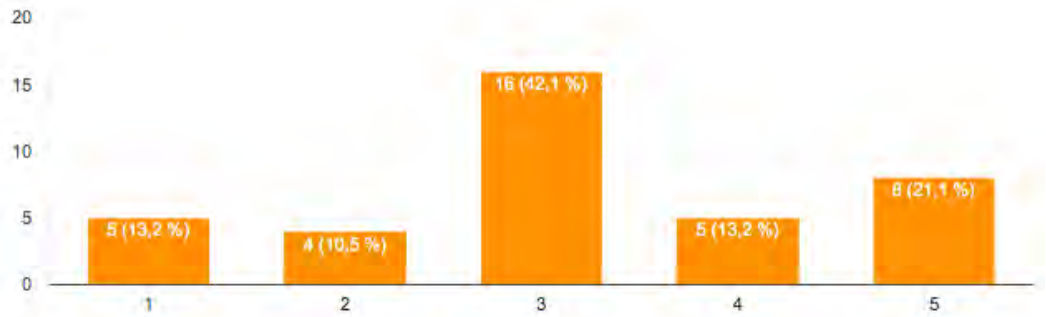
När du går med i ett quiz kan du se vilka andra i din grupp som har gått med. Vad tycker du om detta?

37 svar



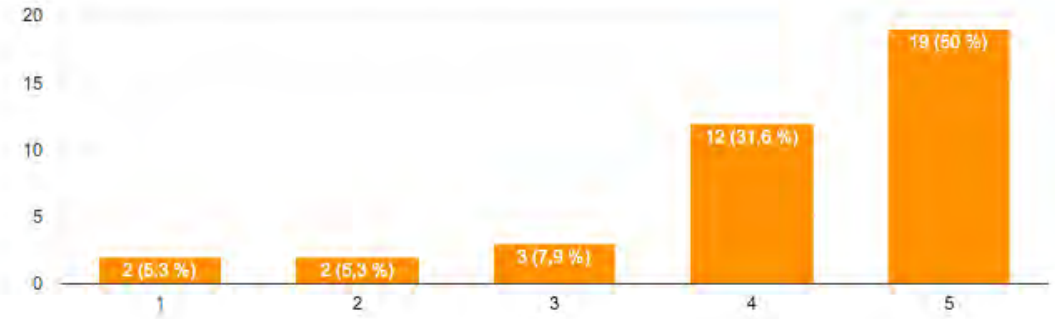
När du spelar ett quiz så kan det komma upp monster längs vägen (inuti appen) som du måste ta dig förbi. Vad tycker du om det?

38 svar



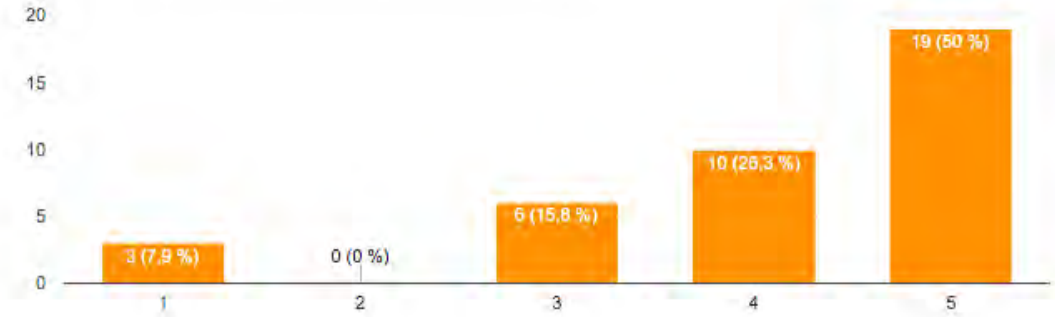
Vad tycker du om att hela klassen kan tävla ihop?

38 svar



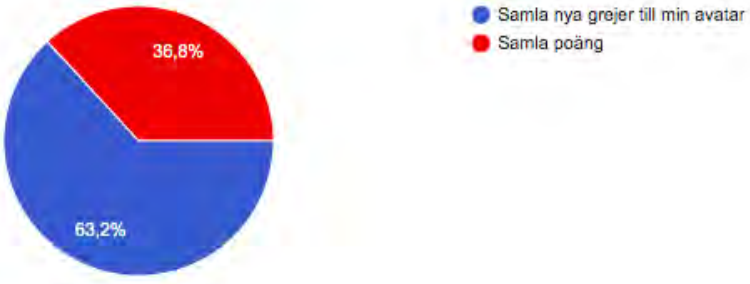
Vad tycker du om att klassen kan tävla mot andra klasser?

38 svar



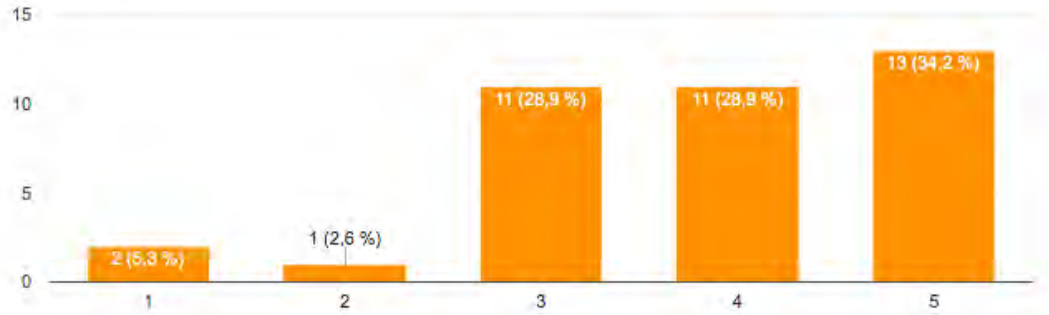
I filmen fick du se att man kan samla saker till sin karaktär, tex en krona. Tycker du det är kul att samla nya grejer till din karaktär eller hade du hellre samlat poäng?

38 svar



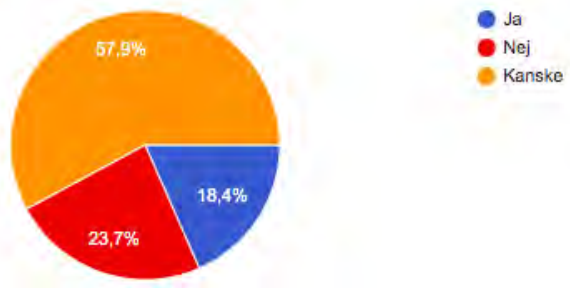
I filmen fick du se att man kan ställa in vart man vill gå i stegräknaren. Är det kul att se sin process och få reda på hur långt man faktiskt har gått?

38 svar



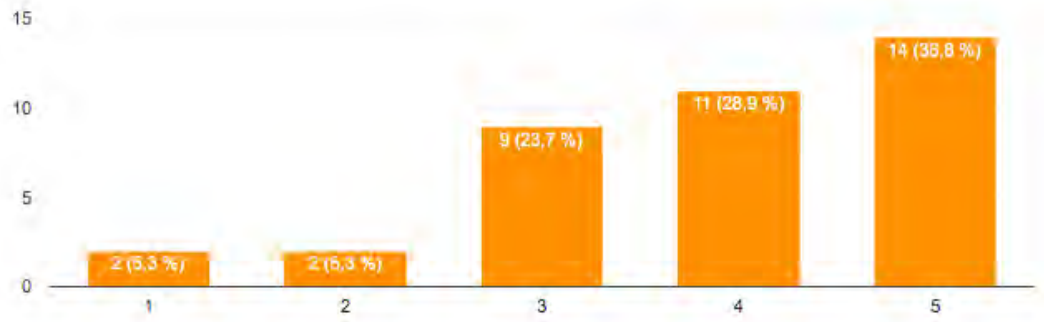
Hade du skapat egna quiz för läxläsning i denna appen?

38 svar



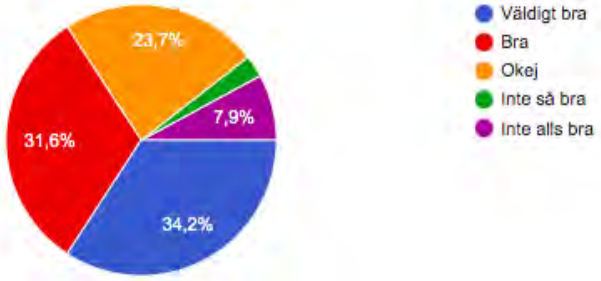
Vad tycker du om att man kan skriva inlägg i grupperna? Till exempel att läraren kan påminna om när nästa test är.

38 svar



Vad tycker du övergripande om spelet ?

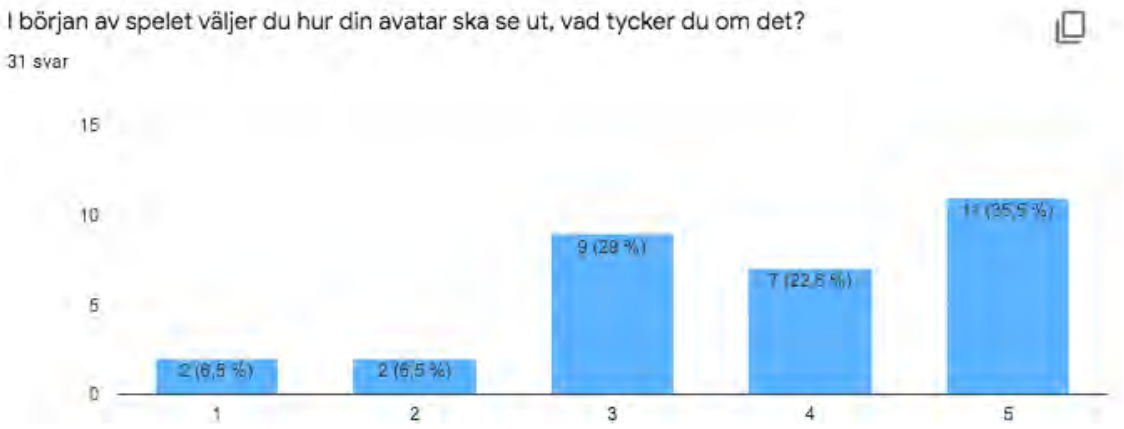
38 svar



I

The result from the testing of the high fidelity prototype with students

The result and questions from the testing of the finale prototype with students.

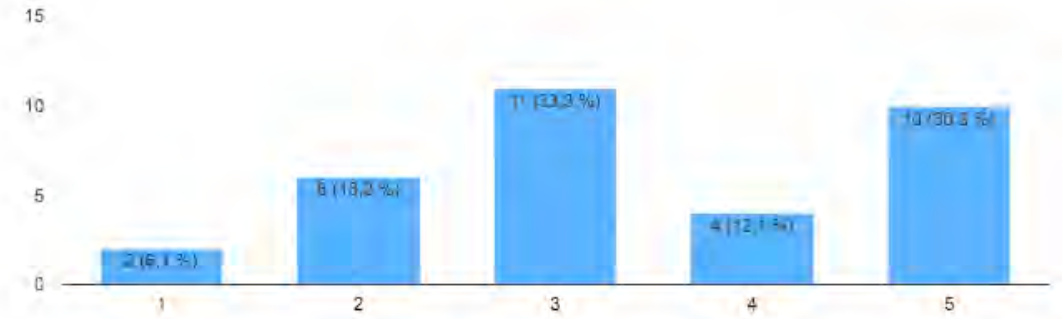



När du svarar rätt på en fråga kan du möta klasskamrater (inuti appen) som du får göra give me five med. Vad tycker du om det?
33 svar
20
15
10
5
0
4 (12,1 %)
4 (12,1 %)
16 (48,5 %)
5 (15,2 %)
4 (12,1 %)
1
2
3
4
5


När du svarat rätt på en fråga i quizet får du välja ett paket av tre av dina klasskompisar. Vad tycker du om det?
32 svar
15
10
5
0
3 (9,4 %)
4 (12,5 %)
14 (43,8 %)
7 (21,9 %)
4 (12,5 %)
1
2
3
4
5

Om du inte vet svaret på en fråga i quizet kan du en gång per quiz trycka på en livboj som visar vad resten av din klass svarat mest på, vad tycker du om det?

33 svar

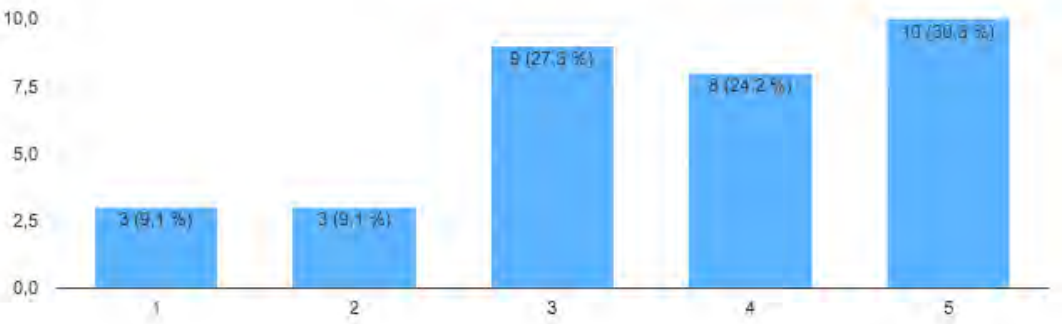


Tycker du det är kul att det är tre av dina klasskamrater som håller paketen eller hade du hellre valt bland tre paket som inte hålls av dina klasskamrater?

33 svar

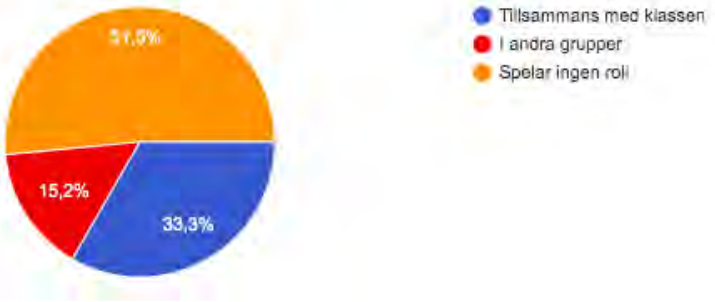
Tycker du det är kul att tävla mot andra klasser?

33 svar



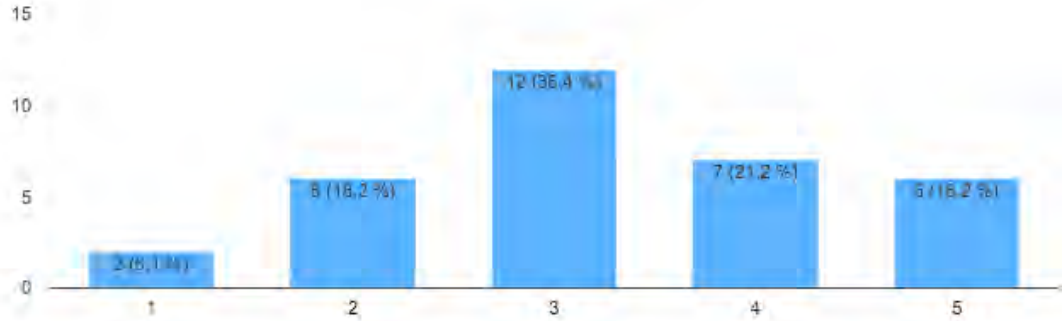
Hade du helst tävlat tillsammans med din klass eller i andra grupper?

33 svar



I filmen fick du se att man får välja ett land att gå till på jordklotet i stegräknare. Vad tycker du om det?

33 svar

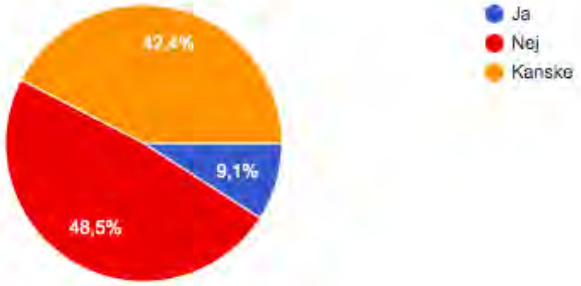


I filmen kan du se att man kan se både hur långt du har gått och hur långt din klass har gått. Vill du både se gruppens sammanlagda steg på på jordklotet och dina egna eller vill du bara se hur långt du har gått?

33 svar

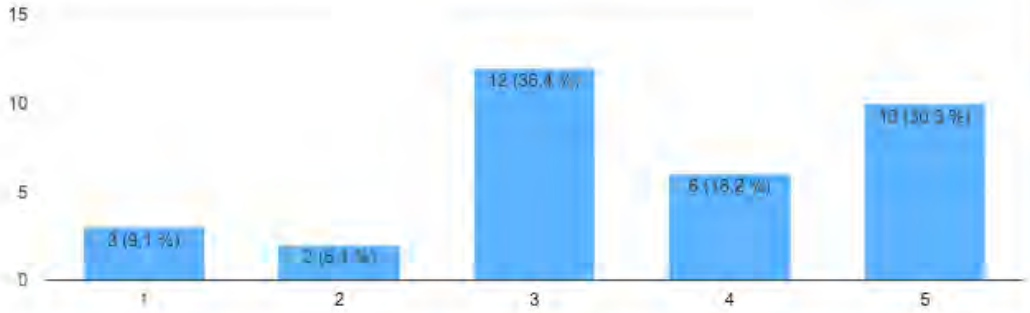
Hade du skapat egna quiz för läxläsning i denna appen?

33 svar



När din klass tävlar mot andra klasser vinner klassen en pokal beroende på vilken placering ni fick. Vad tycker du om det?

33 svar



Vad tycker du övergripande om spelet ?

33 svar