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Increasing physical activity for individuals with intellectual disability through indoor bike cycling and exergaming

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Preface

Exergaming has become a popular subject for research because of its possible beneficial health effect in the population. Today there is a vast number exergames, but not many types that suits to be used by individuals with an intellectual disability. With this project I want to contribute to more focus on exergames customized for individuals with intellectual disability. The attempt to make a product aimed against this so often overlooked group has been both inspiring and meaningful. Meetings with parents and staff from institutions was very motivating due to their enthusiasm that they show for the project.

After four years of studying computer science, game development and front-end development is still a new field for me. The computer science courses I attended have mainly focused on other interesting fields within the computer world. The thought of creating a game and designing a user interface was a bit frightening in the beginning. However, after struggling for a while, solving problems and challenges on a game development platform has been both interesting and satisfying. Personally, I like to stay in shape and exercise due to the health-effect and mobility I experience from it. Which make is particularly interesting for me to investigate using software to motivate and stimulate people to exercise more.

This project is a part of the project “Effects of physical activity with e-health support in individuals with intellectual disability” where Ph.D. candidate Henriette Michalsen is the main contributor. This master thesis should provide a technical solution that may be used in this project. However, this master project will also work as a standalone project with a research, implementation, and evaluation part. The master project will be provided resources from the overall project. For instance, most of the user information and testing will be a cooperation between the two projects.

I would like to thank my supervisor, Gunnar Hartvigsen, for his guidance and support throughout the project. I am also grateful to the co-supervisors Santiago Gil Martinez, Miroslav Muzny, Javier Gomez Escribano, and Audny Anke for their contribution with valuable feedback and guidance.

Others that have contributed/made an impact: Henriette Michalsen – productive cooperation with her Ph.D. project; Elisabeth Andreasen – very helpful with testing at the daycare institution; fellow students in office (Marius, Vebjørn, Sverre and Tobias) – have made the days more enjoyable and given valuable discussions; Antonio Martinez Millana – came with valuable feedback near the end of the project.

At last, I would like to thank my family for their greetings and support.

Valter Berg – 29.05.19

Abstract

Studies reveal that individuals with intellectual disabilities have more sedentary lifestyles than the general population. Regular physical activity is of both medical and social importance, reducing risks of cardiovascular diseases and obesity. Health organizations recommend that everyone should at least engage in 150 minutes of physical activity each week because of the beneficial health effects.

There exist several technical solutions that aim to encourage physical activity. Among these solutions are exergames, where the users must move their body to control game-objects. The idea behind exergames is that a user needs to engage in physical activity in order to play the video game. The point is that it should motivate the user to perform physical activity. Exergames comes in several forms and types on the market today. However, most of them are not user-friendly for individuals with intellectual disabilities. The video-game designs do not adapt to the many challenges that are present for this group.

In this project we developed hardware and software modules to record the amount of physical activity on an indoor stationary bicycle and an ergometer bike. An app receives the recorded activity data and uses it to display entertainment for the user, which makes the app an exergame. The design and development process uses knowledge about individuals with intellectual disabilities to customize the system for this group. Information about individuals with intellectual disability has been gathered through literature searches, conferring with experts, talking with parents of children with intellectual disability, and staff working at institutions providing services for individuals with intellectual disabilities.

The system is tested at an institution where several individuals with an intellectual disability could try it out. Feedback from testing indicates that the users with an intellectual disability enjoyed using the system, and it was a useful tool for the staff to promote physical activity for the users at the institution. Testing also gave valuable information on what should be included in the further development of the system to improve it.

This project has shown that with close user interaction during the development, it is possible to create promising technical solutions for individuals with intellectual disability. The results of this project provide valuable information on beneficial technological interventions for individuals with intellectual disabilities to promote regular physical activity.

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1 Introduction

1.1 Motivation and background

Increasing the amount of physical activity and reducing sedentariness and passivity among people in general, is today emphasized to have medical and social importance (Bull, 1999; Stoltenberg, 2015). The reason for the emphasizing is that it is substantiated to improve the chances of a healthy life and lower chances to get, among others, cardiovascular disease and obesity (Church et al., 2007; Epstein et al., 1985). A general health recommendation tells us that one should be moderate to vigorously physically active at least 30 minutes a day or 150 minutes a week (Bahr et al., 2015; Russell R. Pate, 1996). For the general population, a sedentary lifestyle has been pronounced as a problem in younger people (Winther et al., 2014), although it is likely that for the youth with ID, it is an even more prominent problem (Wallen et al., 2009).

Intellectual disability (ID) is a generalized term for a neurodevelopmental disorder and is used to describe individuals that have a lack of development in several areas (Wilmshurst, 2012). What it means to have ID differs much from individual to individual, but it always is impaired cognitive abilities. To function in daily routine activities is often much harder for individuals with ID than for individuals that have normal development. The term “cognitive abilities” means the ability to perceive, process, remember, consider, retrieve, and act purposefully to the information surrounding us (Direktoratet_for_e-helse, 2019).

It is estimated that there are about 75 000 people in Norway (1.5% of the population) that have a sort of ID (Meld.St.nr.45(2012-2013)). Individuals with ID have, when compared to the general population, more health problems (Balogh et al., 2008), worse coverage of health care needs, and struggles to find sufficient healthcare (Hermans and Evenhuis, 2014; Malt et al., 2013). Individuals with ID have lower levels of physical activity than the general adult population (Hove, 2004), more often struggle with obesity (Hinckson and Curtis, 2013; Maïano, 2011) or other weight disturbances (Bergstrom et al., 2013; Hove, 2004). There was estimated that 50 % of this population has a sedentary lifestyle, and 40% of has low levels of physical activity (Haveman et al., 2011). A Norwegian study revealed that 7% of males and 8% of females with Down syndrome meth the recommendation of 30 minutes with physical activity per day (Nordic Council, 2005). A review found that 9% of the individuals with ID worldwide was able to make the WHO’s recommendation of minimal physical activity (Dairo et al., 2016).

Those who meet the recommended physical activity levels had mostly a mild version of ID, were male gendered, were young, and were living without supervised care (Dairo et al., 2016). Barr M et al. (2011) reveals several barriers for individuals with ID to be in physical activity: families lack time to do necessary support; reduced physical and behavioral skills; and lack of available programs. As a solution to the problems, it is suggested to do more research on successful methods for encouraging physical activity for individuals with ID. The ways for improvements are compound of different aspects (Sundblom et al., 2015). They suggest a better use of theory from intervention designs that should make more robust research designs and learn from intervention studies on community-based settings (Heller et al., 2014).

Technology support in the form of mobile apps is today widely used for monitoring and motivating people in self-management of chronic illnesses (de Jongh et al., 2012; Arsand et al., 2015; Chomutare et al., 2016). Health-related video games can make a behavioral change and promote health with influencing health determent activity (Baranowski et al., 2016). Active video games, also known as exergames, have been investigated and found to be promising for individuals with ID(Lotan et al., 2010; Mat Rosly et al., 2017; Taylor et al., 2016). To realize these solutions outside of the lab, they have to first meet the user's needs by systematic analyzing user wishes (Antypas and Wangberg, 2014). Using touch screen devices, such as smart-phones, tablets, and iPads has proven to have low cognitive demands and could be used to improve commitment to physical activity (Perez-Cruzado and Cuesta-Vargas, 2013).

1.2 Scope and research question

The system made in this project should be used as a tool in the research project "Effects of physical activity with e-health support in individuals with intellectual disabilities", which investigates if a technology-based solution can be used to increase physical activity among individuals with ID (eRapport, 2018). This project shall develop hardware and software modules to record the amount of physical activity on an indoor, stationary exercise bike. The hardware aspect will include to set up a stationary bike with appropriate sensors that measure bike activity. The software part is to design and develop an application (app) that receives the measured data and provide exergame elements.

It is essential that the user gets feedback during the physical activity in order to encourage to continue. Therefore, the designed setup will monitor parameters such as speed and cadence. The activity data should be transmitted real-time to a control unit (e.g., tablet, iPad) that runs the app. A user should be rewarded for cycling extended periods, proportionally. The idea is to take advantage of that many individuals with ID enjoys watching videos or movies, and thus give access to videos when performing physical activity. Individuals with ID are often used to playing videogames on tablets or iPads. Therefore, the system should also provide a computer game functionality controlled by the bicycle. Such a game could be cycling through a landscape with computer game elements, receiving rewards in the form of symbols, animations, and sounds, during exercise.

The main research question of the project is:

> *"How to improve physical activity for people with intellectual disability with exergaming and indoor bike cycling?"*

The issue is how to make a system that is appropriately designed to be used by individuals with ID. For example, it is vital that the system is not too complicated such that it would cause impatience for the user. The entertainment part of the system should work as an incentive to be physically active for the user with ID. As stated, individuals with ID often do not like to be physically active and the content of this entertainment system must apply to user preferences.

The main research question is divided into sub-problems to clarify the scope and boundaries of the thesis even more.

> Question 1: What type of exergame elements would encourage individuals with intellectual disability to use a stationary bike?

To answer question 1, user information must be gathered and taken into consideration. From the gained knowledge, ideas to elaborate on possible solutions from what is reasonable to achieve with the technology available. Then the ideas should be presented to experts and user representants to get a qualitative assessment on what is the most prominent solution to suit the purpose.

The design of the exergame should be customized against individuals with ID, which depends much on the app user interface (UI). The app will be the component that is used to control and present the exergame elements.

> Question 2: What makes an exergame suitable to use for a user with intellectual disability?

To find an answer to question 2, a thorough investigation into research and similar solutions should be used to gain relevant knowledge. Several designs should be made in an iterative process where each design is evaluated with integrating the representants for individuals with ID.

There exists numerous types of exercise equipment and indoor stationary bike solutions. Often individuals with ID is not used to be in physical activity or use exercise equipment. It is necessary to choose equipment and consider if it would suit the purpose of this project.

> Question 3: What type of exercise equipment can be used with and entertainment system for individuals with intellectual disabilities?

The thesis answers question 3 with a consideration of what equipment to use concerning the information of abilities and perhaps limitations individuals with ID have. Also, investigating what equipment that is known to be used by individuals with ID will give an indication of what to use.

1.3 Assumptions and limitations

This project aims to include people with all types of ID as potential users. Those who are potentially interesting in using this indoor bike cycling system could come from a wide specter for degrees of ID. We intended to make the design such that those who have a mild condition of ID can perform exercise sessions on the system by themselves. For those who are not able to manage the system by themselves, it is assumed that they will receive guiding support from parents or staff members at an institution, that guide them during a session. It is preferable if even those with a more severe degree of ID would learn how to operate it with using longer time to practice. For instance, some of the users might learn how to operate the system by being guided for a long time, while others will need guidance every time.

Experts told that it is often difficult to interact directly with individuals with ID to do interviews or questionnaires as they often do not understand what the purpose for them is. There is also an ethical aspect when collecting sensitive data from individuals with ID. The usage of the information gathered from individuals with ID is strictly regulated to ensure data privacy. Written consents should be gathered from all representatives to ensure that there is a common understanding of what happens with the data gathered. Interviews with relevant personnel after tests must be considered carefully not to reveal the identity of participants in testing.

The research that was conducted for this project showed that there exist several options in exercise equipment for indoor biking, but none of them were aimed against individuals with ID. It is appearing from the systematic review conducted in this project that it has not been so many studies that aim to make technical exercise support for individuals with ID. This means that there does not exist a substantial data foundation for this research paradigm that this project can build on. To find a solution, educated guesses and theoretical based decisions will support the design choices. Then it must be tested realistically to see if it succeeded.

This project will not evaluate how such a system will function to motivate individuals to do a physical activity over a longer perspective. For such an evaluation, the time perspective of a master thesis is not enough to investigate long term effects. This project shall contribute a technical solution and evaluate if individuals with ID can operate it and perform physical activity.

1.4 Methods

The process of this project has an experimental design inspired by the paradigms explained in the report “Computing as a Discipline” by Comer et al. (1989). Through theoretical research, ID is defined, and it is enlightened how individuals with ID relates to exergames. With the theoretical knowledge gathered it is determined if such relations are viable. In this project it is predicted that since individuals with ID enjoys watching videos and movies, in addition playing video games, it can be used to create an exergame that individuals with ID will enjoy. Then the requirements and specification are stated before making the design and implementation. In the end the system is tested.

This project has created a prototype based on information from experts within the field, meetings with parents and healthcare personnel, and a review on state-of-the-art regarding bike exergames and intervention studies for ID and exergames. The development process adapts the participatory design, “a set of theories, practices, and studies related to end-users as full participants in activities leading to software or hardware computer products and computer-based activities” (Muller, 2003). The design development will elapse as an iterative process that involves making a design, present it for user representatives and receive feedback.

The work presented in this paper conducts the following:

- Review of available products for bike exergaming on the market.
- Review of available activity apps that are customized for individuals with ID.
- Review of studies that does intervention with intellectual disability and exergames.
- Interaction with user representatives such as experts, parents, and institution staff members.
- Research on important aspects with exergames, ID, and behavioral change, and the relation between these.
- Develop a paper prototype
- Receive feedback on the paper prototype from experts, parents and institutions staff members.
- Implementing a prototype of the system designed
- Analysis of design implemented and test results.

1.5 Significance and contribution

The main contribution of this project is to provide an exergame solution that is custom made for individuals with ID. With a systematic search, it is revealed that there are few studies that investigate the intervention of individuals with ID and exergaming. Several solutions for exergaming related to bike cycling exists, but they are not user-friendly towards individuals with ID. By doing research and using close user interventions during development, this project has made a reasonably priced prototype customized against individuals with ID (Figure 1). Testing of the system in a realistic environment has given indications that this prototype has succeeded in being user-friendly for individuals with ID.

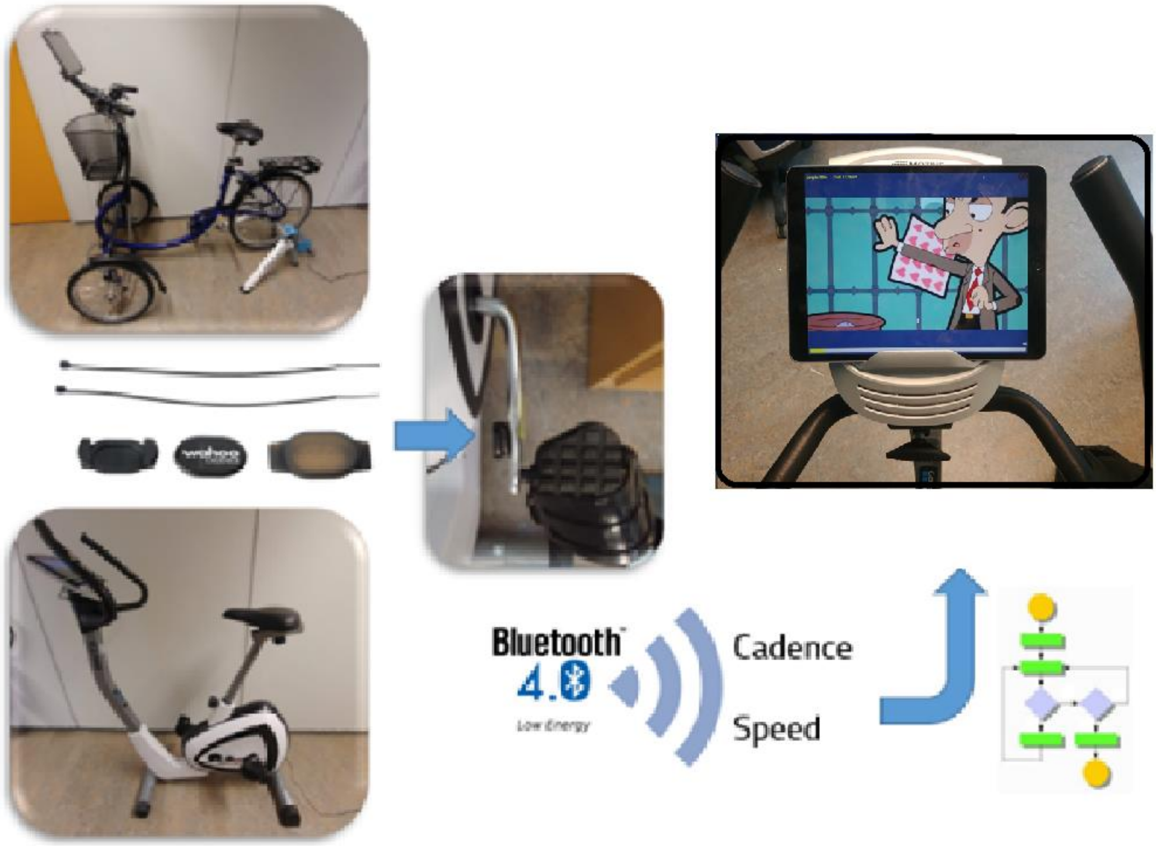

Figure 1 System outline, mount stationary bikes with sensors, and use activity data in an exergame customized for individuals with intellectual disabilities.

This project is expected to extend the possibilities for e-health support for physical activity among people with ID. The product made in this project will gain specialized healthcare services a tool for investigating e-health support to improve lifestyle among individuals with ID. If the product is found useful, it should help individuals with ID to become more physically active and thereby improving their physical fitness, health and mental well-being. This project also shows techniques for creating technical solutions for individuals with ID. These techniques have appeared to be promising and may be used in studies that aim to investigate this field further.

1.6 Organization

Chapter 2. Theoretical Framework - provides general information and background of the thesis. The chapter contains relevant information about intellectual disabilities (ID) and the concept of exergaming. After the necessary knowledge is stated, it will continue with a systematic review of the literature inside the scope of ID and intervention with exergames and other relevant games.

Chapter 3. Materials and Methods - explains the materials and methods that were used to design and work on this project. The development process for this project is inspired by the engineering paradigm found in the task force committee report called “Computing as a discipline” by (Comer et al., 1989).

Chapter 4. Requirements and Specification - describes the functional and non-functional requirements for the project. The presentation method of the requirements is inspired by the Volere Requirements Specification(Robertson and Robertson, 2013).

Chapter 5. Design – describes the design process and how the final design which fulfill the requirements.

Chapter 6. Implementation – explains how the design has been implemented with details about important aspects with the technology and how it was used.

Chapter 7. Test and Results – explains what types of tests that have been conducted and presents the results from this testing.

Chapter 8. Discussion and Future Work – discusses the results of the project and how it addresses the challenges and problems presented in the introduction. The chapter investigates relevant work and discusses differences and contribution in this project. It gives a summary of what ought to be done to improve the prototype in further development.

Chapter 9. Conclusion – presents the perspectives of the project and concluding remarks.

2 Theoretical Framework

This chapter provides general information and background of the thesis. It contains relevant information about intellectual disabilities (ID) and behavioral change. An explanation on exergames is given, and some examples of bike exergames. After the necessary knowledge is stated, it will continue with a systematic review of the literature inside the scope of ID and intervention with exergames.

2.1 Intellectual disability

There may be several reasons for having an ID diagnose, but often, the cause has a genetical explanation (Direktoratet_for_e-helse, 2019). To be defined as an individual with ID requires a deficit in reasoning, problem-solving, abstract thinking, or other intellectual functioning; confirmed with a clinical and intelligence testing (Colman, 2015). Setting the ID-diagnosis to an individual, requires an intelligence quotient (IQ) score below 70, i.e., two standard deviations (-2σ) below the mean of the normalized IQ distribution, which is 100 (Goodman and Scott, 2012). A categorization for ID based on the severity of the diagnosis comprises mild, moderate, severe, and profound (Luckasson et al., 2002). Individuals with mild ID has an IQ between 50 and 70, those with moderate ID has an IQ between 35 and 49, those with severe ID has an IQ between 20 and 34, and those with profound ID has an IQ between 0 and 20 (Daily et al., 2000; ICD-10).

To diagnose a child with mild ID until after starting school is often difficult. While poor academic performance can be recognized, it can be hard to differ mild ID from a specific learning disability or emotional/behavioral disorders (Sigafoos et al., 2010). To set a diagnosis to mild ID might require a thorough assessment from experts and an extensive series of tests. An individual with mild ID often have these characteristics: can acquire practical skills, may have no unusual physical signs, has some skills in math and reading, can conform socially, and can be integrated into general society (Luckasson et al., 2002).

Individuals with moderate ID have more obvious developmental delays then mild ID and recognizing the diagnosis is more often done during early childhood. Commonly, individuals with moderate ID are more likely to have a known cause of receiving the diagnosis (Sigafoos et al., 2010). Developmental characteristics of moderate ID are: noticeable delays in speech; some unusual physical signs; can learn simple communication; can learn elementary health and safety habits; can participate in simple activities and self-care; can perform tasks in sheltered conditions; and can travel to familiar places (Luckasson et al., 2002).

Identification of severe and profound ID is often easily discovered in infancy as the individuals have a significant developmental delay. The learning and behavioral deficits for individuals with severe or profound ID are often so grave that obtaining a reliable score on an IQ test is difficult (Sigafoos et al., 2010). Individuals with severe or profound ID often have major health-related problems such as epilepsy and sensory and physical impairments (Amiet et al., 2008). The characteristics of severe ID are: marked and noticeable delays in movements; little or no communication skills; might understand and show some response to speech; may be trained in simple self-care; and almost always need direction and supervision (Luckasson et al., 2002). Individuals with profound ID are not capable of self-care and are even more dependent on help in day-to-day activities that individuals with severe ID are (Luckasson et al., 2002).

To summarize the challenges, individual with ID may have several of these characteristics: short attention span; poor judgment; impulsive behavior; slow learning; reading is slow and laborious; concentration tends to fluctuate; poor physical coordination; difficult remembering information; difficult with organizing and planning; difficult working within time limits; difficult thinking and working in sequences, which can make planning difficult; visual processing difficulties, which can affect reading and recognizing places; poor auditory processing skills; listening to oral instructions difficult, tiring and confusing (Bigby et al., 2014; Einfeld and Emerson, 2008; ICD-10). These are important aspects to think of when making products for individuals with ID (Seeman and Cooper, 2019).

2.1.1 Behavioral change in individuals with intellectual disability

Several studies have identified barriers that cause individuals with ID to have low levels of physical activity (Bossink et al., 2017). Lack of motivation is emphasized as one of the reasons for not being physically active for individuals with ID (Dixon-Ibarra et al., 2017; Temple and Walkley, 2007), and is related to that they do not understand the benefits of exercise (Hawkins and Look, 2006). Other barriers that were pointed out were a lack of options for physical activity and programs aimed for individuals with ID (Mahy et al., 2010); or that physical activities were too difficult or boring (Heller et al., 2003). For those of the individuals with ID that are interacting with staff at institutions, it is said that the staff may lack interests, skill, knowledge or confidence in physical activity, such that they are not able to support individuals with ID to be physically active in a good manner (Temple and Walkley, 2007).

In addition to revealing the barriers, the studies also make suggestions on how to facilitate all these barriers (Bossink et al., 2017). Van Schijndel-Speet et al. stated in their study that it would be beneficial to increase staff knowledge on physical activity and available options in physical activity options and materials (van Schijndel-Speet et al., 2014a). Rewards and being praised for performance in forms of feedback, medals, or awards, has proven to be a promising way to give interest in physical activity for individuals with ID (Barr and Shields, 2011; van Schijndel-Speet et al., 2014a).

Behavioral change is a well-studied research field within psychology, where they evolve theories on how behaviors change (Abraham and Michie, 2008). There have been conducted reviews to identify different behavior change techniques and to look at intervention efficacy (Abraham et al., 2015; Albarracín et al., 2005). Abraham and Michie (2008) present a set of accredited behavior change techniques with a definition of each of them. Based on the knowledge about barriers and facilities mentioned above, a specific technique Abraham and Michie (2008) is enhanced to be relevant in this project; *Provide contingent feedback*, which they define as “Praise, encouragement, or material rewards that are explicitly linked to the achievement of specified behaviors.”

Response-stimulation has proven to be a promising strategy for encouraging behavioral change in individuals with ID where a certain behavior gives a preferred stimulus (Shih et al., 2010; Lancioni et al., 2009). Chang et al. (2014) used preferred environmental stimulation that was related to the activity performed on an ergometer bike. They tested the system on two adolescents with intellectual disability, which used the ergometer bike combined with watching their favorite music video as a reward. The results from Chang et al. (2014) showed that the intervention gave an increase in the test persons' engagement in physical activity. However, they point out that they were only able to conduct short test phases, and that the results should be taken as good indications for such a system to work on the long term. These examples are under the contingent feedback-technique for behavior change and do propose that this technique will work on individuals with ID.

At the seminar "Physical activity with E-health support with individuals with intellectual disability," an expert[1] in the field of behavioral change had a presentation on motivation and rewards. The expert talked about inner and outer motivation. Inner motivation can be joyfulness, meaningfulness, and a sense of coping, while outer motivation can be receiving candy or money, or getting punished. The long-term effect on behavioral change was more likely to be achieved using inner motivation. However, appalling to inner motivation requires high cognitive capacity at the user, so even if it is preferred, it will be hard to use with individuals with ID. The expert said that for individuals with ID, it should be attempted to combine inner and outer motivation, such as making a behavior joyful and use immediate outer rewards such as entertainment or candy.

2.1.2 Intellectual disability and technology aid

Guidelines for technology design

The World Wide Web Consortium (W3C) has a Cognitive Accessibility User Research where they investigate challenges of using web technologies for people with learning disabilities and developmental disabilities, including an own section on intellectual disabilities(Seeman and Cooper, 2019). Many of the aspects W3C discuss as vital design choices for web technologies regarding users with intellectual disability, apply to app designs as well.

To adapt to the challenges ID have, the W3C user research recommends a set of practices. Here is a selection of some of them relevant to apps (Seeman and Cooper, 2019):

- *Use plain, evenly spaced, sans-serif fonts, such as Arial or Comic Sans*
- *Use dark-colored text on a light (not white) background.*
- *Avoid underlining and italics. Use bold instead.*
- *Use boxes and borders for effective emphasizes.*
- *Use short, simple sentences in a direct style.*

[1] Silje Wangberg, psychology professor

- *Give instructions clearly.*

Activity app from Den Norske Turistforening (DNT)

DNT has created an app for individuals with ID, called Friluftsliv Tilrettelagt for Utviklingshemmede (FTU). The project behind the FTU apps wants to make it easier for individuals with ID and their families to enjoy outdoor activities (Tvilde, 2017). In the app, there is an overview of event schedule over activities that are aimed against individuals with ID. The info about the activities is gathered from municipality services or organizations that arrange such activities. The app provides information with symbols, short text or long text, and vocal audio of the text (Smart_Cognition_AS, 2019). An audio and symbol description will help those who struggle to read.

The creators[2] of this app kept a presentation at the seminar "Physical activity with E-health support with individuals with intellectual disability," where they shared their experience with design of an app and usage for individuals with ID. They emphasized the importance of predictability and how the app should express what is happening for the user. The solution with having the option with both full text, short text, and audio for explaining elements, are success factors for the app.

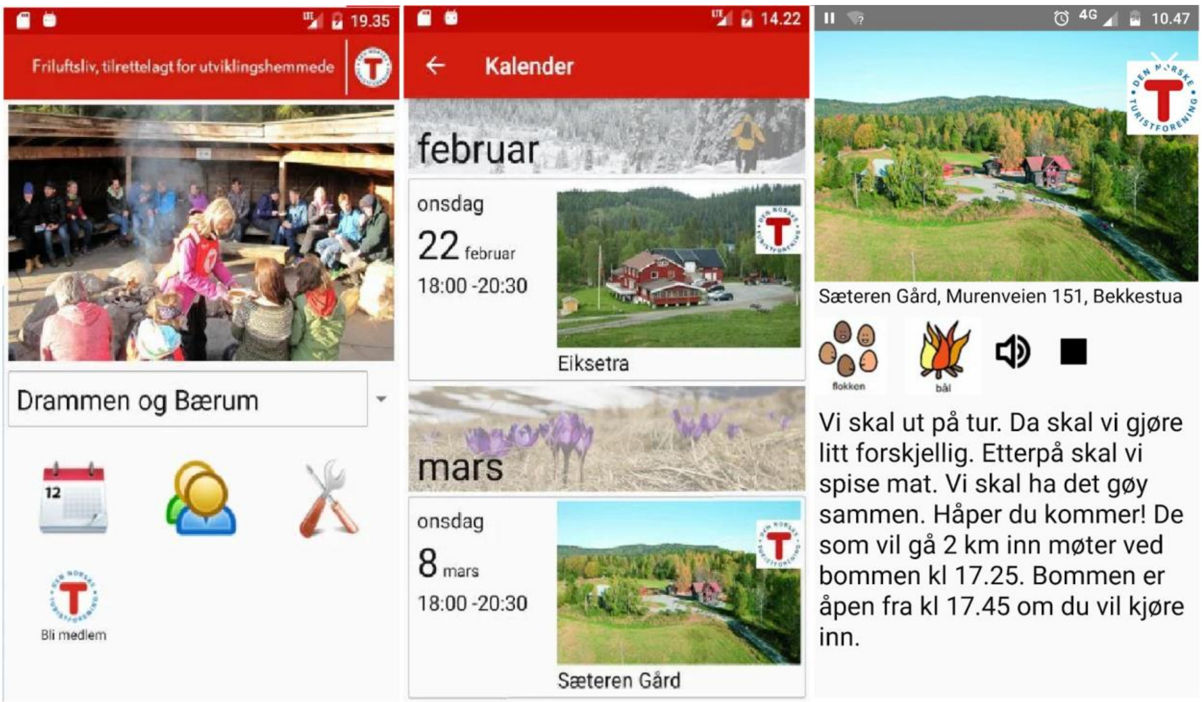

Figure 2 Screenshots showing an event description in the FTU App, from (Smart_Cognition_AS, 2019)

[2] Eirik Dahl, project manager, and Sven Erik Tønnesen, general manager Smart Cognition

Search for activity-apps for individuals with intellectual disability

A search for apps in both Google Play Store and Apple's App Store was done for apps that function as activity-apps for individuals with ID. The search was conducted with the search keys: "Intellectual disability" and "developmental disabilities." This search yielded one result in Google Play Store, a game called *FunDoRoo (FunDoRoo, 2018)*. This game is developed to improve motor skills in youth with and without developmental disabilities. The app contains an activity plan, instructions on how to do several activities, and an overview of activities that are done. As the game uses text to describe most actions and information, it does not suit many individuals with ID, since most of them cannot read.

2.2 Exergaming

Exergaming, also known as active video games (AVG), is defined as a video game that requires bodily movements to control the game (Benzing and Schmidt, 2018). Recent surveys reveal that 96 percent of Norwegian boys and 63 percent of Norwegian girls play video games (Medietilsynet, 2018). Video gaming is an everyday activity for children and youngsters that in most cases, result in sedentary behavior (Sjödin et al., 2011). In contrast to regular video games, exergaming provides both exercise and a video game at the same time (Staiano and Calvert, 2011). Several terms are used for exergames, such as "active video games," or "interactive video games," and one of the explanations given are "Any type of video games/multimedia interactions that require the game player to move physically" (Oh and Yang, 2010).

Exergames are involved in several intervention studies that investigate the health-related benefits of using exergames (Maroni and Bardal, 2018; Staiano and Calvert, 2011). *Games for Health Europe* is a non-profit organization founded by Jurrian and Sandra van Rijswijk in 2010 that wants to bring together health care development games[3]. In 2018 they released six issues of the journal containing 48 studies related to the use of games in health interventions. A search on Google Scholar in the journal after exergames gives 12 results that have "exergame" in the title since after 2015. These studies give indications that exergaming is becoming an interesting aspect of the scientific world.

2.3 State-of-the-art

This section will try to present the current state-of-the-art on exergames that involves indoor bike cycling. There is also conducted a systematic literature review on interventions between ID and exergaming in general.

2.3.1 Bike exergames examples

There are several solutions for bike exergames that have similarities to this project's system. The solutions that are most alike and prominent in the market are mentioned below.

[3] https://www.gamesforhealtheurope.org

Expresso GO Upright

Figure 3 Expresso GO Upright, an ergometer-bike exergame (Interactive_Fitness, 2019).

The Expresso GO Upright has a 26.5-inch touchscreen mounted in front of the handlebar that displays an entertainment system. The entertainment system provides 43 different tours on interactive roads; and nine different maps for game mode. If there are two or more bikes connected on the same network, it is possible to ride together, real-time, on the interactive roads. It is possible to challenge other people with similar properties (age, gender, shape) and get an overview in a leaderboard. The game mode provides virtual worlds were items such as dragons, stars, and coins are collected by hitting them. (Interactive_Fitness, 2019)

Playpulse

Figure 4 The Playpulse system[4].

Figure 5 Screenshot from one of the games offered in Playpulse.[4]

Playpulse is a gaming platform that provides multi-player mode combined with a component that turns an ergometer bike into a game controller. Several bikes are set up together, and then people can play different games, both with and against other players and the computer.[4] This system is available to companies, such as gym centers, where it can be installed in several units.

[4] https://playpulse.no

Mobile applications

There exists a market with apps made for smart-phones or tablets/iPads that combined with a stationary bike, functions as a bike-exergame. A search for such apps was conducted on Google Play Store[5] and in App Store[6] with the search keys: "exercise bike," "ergometer bike," "bike trainer" and "stationary bike."

Table 1 Available exercise bike games May 2019.

App name	Available at	Price	Short Description
Vescape (Vescape, 2019)	App Store/ Play Store	Subscription 85NOK/month	Provides interactive video-game where exercise bike mounted with sensors functions as game-controller.
BitGym: Virtual Cardio Tours (BitGym, 2019)	App Store/ Play Store	Subscription 7.99USD/month	Uses the front camera on tablet/iPad to register activity movements. Let you travel on tracks recorded from all over the world. Provides a few tours for free but requires a subscription to gain full access.
Zwift (Zwift_Inc, 2019)	App Store/ Play Store	149NOK/month	Let you ride virtual bike tracks from around the world, challenging others online. Connects with most available bike sensors in the market. Can adjust the resistance on power wheel after hills and slopes in game.
Tacx Cycling app (Tacx_B.V._and_Tacx _International, 2019)	App Store/ Play Store	In-app purchase 119 NOK/track	Play cycling videos from famous bike tracks using exercise data from bike sensors. Can also adjust the resistance on power wheel to adapt hills and slopes in videos. Provides three short demo track videos.

The result from the search of stationary bike-exergame apps is shown in Table 1. Several apps recorded stationary bike exercise data, such as cadence, speed, distance and power consumption, and then displayed it with labeled text. These apps were not included in the list as the objective was to find apps that included game-elements combined with the exercise. The game-elements could a visually way of showing progress without using text or only a progress bar.

[5] https://play.google.com

[6] https://www.apple.com/

Figure 6 Screenshot from Tacx Cycling App. (https://tacx.com)

All the apps that were found were aimed against typically developed people or professionally cyclists. Apps, such as the Tacx Cycling App (Figure 6), focuses on displaying bike exercise data, such as speed, distance, and power usage, both during exercise sessions and in a statistical summary afterward. Except for three demo sessions provided in the Tacx Cycling App, regular training sessions often have an estimated duration time of over an hour. Doing exercise sessions that last more than an hour and paying attention to bike exercise data, applies to users that are experienced bike cyclist or interested in the cycling sport. BitGym Virtual cardio Tours was the only app that did not record advanced bike exercise data as it only used the front camera to register motion.

This search is limited to Google Play Store and Apple's App Store, and apps that are published other places are therefore not found or considered.

2.3.2 Systematic review

The structure for finding relevant literature is inspired by the PRISMA methods for systematic reviews and meta-analyses (Moher et al., 2009).To find relevant literature the following search keys were used *("intellectual disability" OR "cognitive disabilities" OR "mental retardation" OR "developmental disabilities" OR "mental handicap" OR autism OR "Down syndrome") AND ("exergame" OR "video game" OR "video-game" OR "serious game" OR "exercise bike") AND ("physical activity" OR fitness OR exercise)*. These keys cover a broad specter within the wanted/desired scope of literature.

The literature found in this section comes from a systematic search through these databases: Scopus, IEEE (Institute of Electrical and Electronics Engineers) Xplore, PsycINFO American Psychological Association, PubMed (National Library of Medicine and National Institute of Health), Web of

Science, ACM (Association for Computer Machinery) Digital Library and Science Direct. For the search conducted in the databases IEEE and ACM, the search key specter was extended as it is assumed that a search for literature on ID is limited in such technical databases. The records about ID in these databases were also likely to be an intervention between ID and technology. How the different databases gave results is shown in a table in Appendix 1.

An inclusion criterion was set to clarify what papers should be included further in both the screening and in the full-text evaluation. All papers accepted as relevant could show a user study of intervention between individuals with ID and exergaming. There was not set a criterion for the type of exergame used in the intervention to achieve a broader selection in papers. The exergame did not specifically have to involve bikes since it provided few results when added in the criteria. The screening process also excluded posters, short papers, and studies that were under progress as well as papers that are not peer-reviewed. It was preferable that the papers presented a user study and proof of concept, but the result included some papers that made qualified professional assumptions. The review process revealed that there are not so many studies on the specific intervention between ID and exergaming, and therefore, the screening includes papers that had no user study.

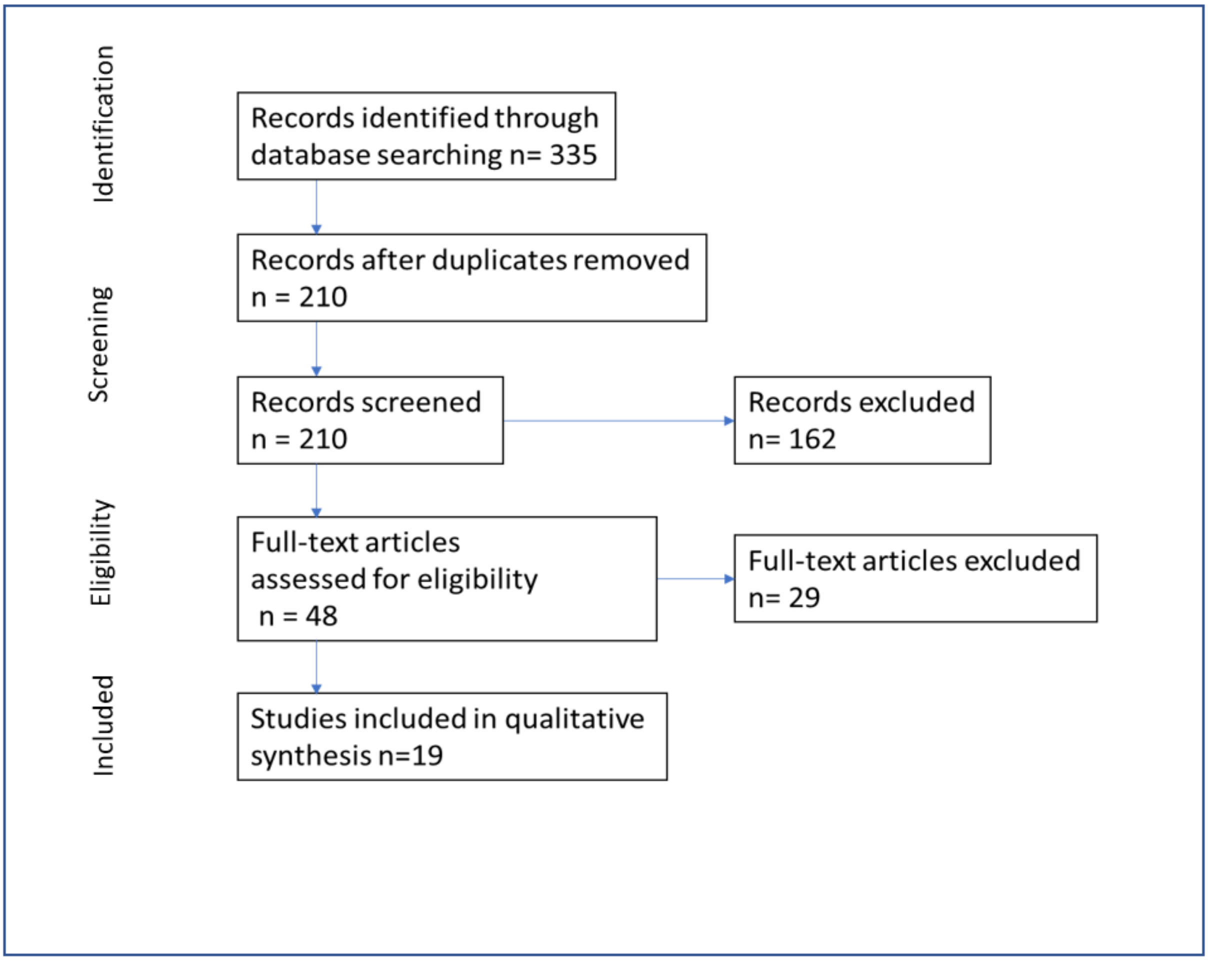

Figure 7 Selection on the literature for intervention between exergaming and individuals with intellectual disabilities. Inspired by the PRISMA statement.

The records found where first assessed by reading the title and abstract in a screening. Then the accepted records in the screening process were parsed for eligibility be reading the full text of each record before including them as relevant literature. Some papers that were not available were removed during the systematic literature review. Figure 7 illustrates the results from the systematic literature review, where the number of records is reduced through an identification, screening, inclusion by eligibility, and the final accepted papers.

2.3.3 Limitations

There was also performed a search in Google Scholar with the same key-words that yielded over 3000 records. When looking into to 50 first hits appearing, all records that were screened relevant had already been found. Due to time limitation, a further look-up in Google Scholar was not conducted, and this search is not considered in the systematic review. There is also a possibility that the key-words used do not cover all possible relevant research and that use of more synonyms could have given more records as a result.

2.3.4 Findings

Included papers from the systematic literature review are listed in Table 2. The table indicates the type of ID and game that an intervention studied. Then it presents some of the most relevant vital findings considering the goals of this project. The most recent research is listed first, and then it goes backward in time. The oldest research included is from 2011, but it has not been a time limit used in the searches. It is reasonable to think that the time frame of the research found relates to releases of popular exergames. Video game controllers, such as Xbox Kinect was released in 2010 (Olsen, 2017), while the Nintendo Wii was released in 2006 (Sanders and Casamassina, 2006).

Table 2 Table of articles included after full-text assessment for eligibility.

Paper	Target Population	Game type/ topic	Relevant key findings
(Macias et al., 2018)	Individuals with Down Syndrome	Kinect Monsters, hand movement to move objects. Objective: Motor coordination exercise	Were able to perform tests on 10 participants in a controlled setting with a therapist. Children needed more assistance then adolescents with down syndrome. Children were more encouraged by prompts, both with voice and visual ones.
(Lee et al., 2018)	Individuals with Autism Spectrum Disorder (ASD)	Puzzle Walk, augmented reality, puzzle-solving Objective: Physical activity	Not tested, but focused on features such as prompting self-monitoring of behavior, instructions on how to do a behavior, prompting rewards toward the behavior and successful outcomes, feedback on performance and goal setting.
(Kurnaz and Yanardag, 2018)	Individuals with Autism Spectrum Disorder (ASD)	Video self-modeling (VSM), Objective: Motor coordination exercise	Tested on four participants with ASD. Showed that VSM could be used to promote physical activity in leisure time among individuals with ASD.
(Golden and Getchell, 2017)	Individuals with Autism Spectrum Disorder	Xbox Kinect, on-screen avatar controlled by near-infrared technology that registrars' movement Objective: Motor coordination exercise	States that since video games are popular among individuals with ASD, an intervention with this interest gives a higher probability for success with repetitive activities. Active video games provided physical activity levels that were enough to contribute to the recommendation of time in physical activity each day.
(Edwards et al., 2017)	Individuals with Autism Spectrum Disorder	Xbox Kinect used to play tennis, baseball, soccer, etc. controlled by near-infrared technology that register movement	Some of the positive aspects with AVG noted by parents of test group: such as flexibility of gameplay, appeal to children's interests and ability, increase the amount of actual physical activity and reduce idle time.

		Objective: Motor coordination exercise	Limitations: little test group, no measure of the intensity of the activity.
(Carrogi-Vianna et al., 2017)	Individuals with down syndrome	Nintendo Wii, bowling and golf video games Objective: Motor coordination exercise	The video game type in this research can be used to practice acceleration movement and improve motor performance.
(Caro et al., 2017b)	Individuals with Autism Spectrum Disorder	FroggyBobby3.0, control frog avatar with hand movements. Objective: motor coordination exercise	An exergame that can be used to support children with motor problems when practicing motor coordination exercises and eye-body coordination. Design insights on defining features for an exergame aimed against children with motor problems.
(Caro et al., 2017a)	Children with severe autism	FroggyBobby, Objective: control eye-body coordination	Experiences that it is important to use visual stimuli to guide children's movements.
(Vazquez et al., 2016)	Children with autism	Musical game Objective: practice motor movements	Uses the Neuro-Music therapy to encourage children to perform movements in front of an interactive screen, e.g., make a bird sing.
(Strahan, 2016)	overweight/obese adolescents with Autism Spectrum Disorders (ASD)	Rate «Everyone » Entertainment Software Rating Board and were considered suitable for ages 6 years and older Objective: effect on obesity through increasing physical activity	Tested on four adolescents with mild to moderate ASD. Tested AVG for six weeks. Preliminary evidence that active video game playing has a positive effect on obese adolescents with ASD. States that there is a significant gap in extant literature.
(Flynn and Colon, 2016)	Children with special needs, e.g., Autism Spectrum Disorder (ASD) and Attention-Deficit Disorder (ADD)	Nintendo Wii dance game Objective: execution functioning	The children enjoyed playing AVG. When they played alone the effect on executive functionality was more effective when playing with a peer. Suggest a limitation on children with special needs playing collaboratively.
(Dickinson and Place, 2016)	Individuals with Autism Spectrum Disorder	Nintendo (Kyoto, Japan) Wii, e.g., table tennis Objective: improve social functioning	The results show that, at least in boys, such a program has the potential to produce a positive change to social functioning.

(Davison et al., 2016)	Behavioral health disorders, ASD, ADHD	Espresso™ virtual bike Interactive Fitness Corporation. Objective: improve behavioral regulation through increased physical activity	Large study with 109 participants over a year. With the use of cyber cycling in an exercise program called Manville Moves, they were able to provide experimental evidence that the program could give behavioral and cognitive benefits for children in a therapeutic school setting. States that children with mental disabilities have low participation in sporting leagues and individual completive sports, and because of that they are likely to be wagered to perform and participate by receiving ribbons, medals, and trophies.
(Foran, 2015)	Individuals with Autism Spectrum Disorder	Kinect Sports tennis exergame Objective: increase physical activity	Case study. Five adolescents, six sessions over 3-6 weeks. Thinks that in-home intervention study with AVG is feasible and realistic. Calls exergaming a promising way to counterattack obesity among youths with ASD.
(Chang et al., 2014)	Students with intellectual disabilities	Environmental stimulation, favorite video, and sound. Play on activity on an exercise bike Objective: increase physical activity	Tested with two students with ID. Tested for ten 3min sessions over five days. Reveals that the intervention had a positive effect of increasing the pedaling activity for the two students it was tested on.
(Finkelstein et al., 2013)	Children with autism, ASD	Astrojumper in virtual reality screened in a room while wearing sensors Objective: Increase physical activity	Ten participants in the test. Two test sessions over two weeks. Most of the participants were able to receive a vigorous activity level, and many of them had high levels of exertion during the majority of the game time.
(Sato et al., 2012)	Individuals with ASD	Objective: Made a game to practice body posture control	Observed the importance of a game to be simple and easy to use, but it should not induce stereotypy of ASD. The games were a suitable method for users with ASD.
(Cai and Kornspan, 2012)	Students with developmental disabilities	Nintendo Wii Tennis Objective: increase physical activity	No testing, theory observations only. Based on observations made, they believe that the game can be used as a helpful tool to teach students with disabilities how to play tennis to be physically active.
(Anderson-Hanley et al., 2011)	Individuals with ASD	Dance Dance Revolution and	Initial evidence on that exergaming may be useful to decrease repetitive behaviors and increase executive function. No

		Expresso 3R with game Dragon Chase Objective: reduce repetitive behaviors and increase executive functioning.	measure on exertion and physical activity level during an intervention.

Comments on findings

In the 19 studies that were included in the table, 14 of them were aimed against individuals with Autism Spectrum Disorder (ASD). ASD is a developmental disorder and is not necessarily included under the term ID. The studies that were aimed against individuals with ASD were included since this group has, like individuals with ID, a problem with a sedentary lifestyle (Pan and Frey, 2005; Eaves and Ho, 2008). The studies with an ASD intervention also show aspects with how to manage behavioral change with the help of exergames. There are three studies with an intervention on individuals that have ID ((Macias et al., 2018); Carrogi-Vianna et al., 2017; Chang et al., 2014), while two studies have an intervention with individuals with developmental disabilities (Cai and Kornspan, 2012; Flynn and Colon, 2016).

The objectives for using exergames differed between the studies; seven studies looked on increasing physical activity, while eleven studies had a focus on a form for motor coordination control, and one study investigated effects on social functioning. Among the seven studies that focused on physical activity, five of them had done a form for user testing. The most thorough testing was conducted by Davison et al. (2016) where they were able to test an exercise program involving exergames on over 109 students for a year. However, these test participants had developmental disorders that do not come under the qualification of ID, which weakens the relevance of the results for this project.

There are then four studies with user tests that as focus on physical activity and use of exergame among individuals with a developmental disorder. One of the four studies were aimed against individuals with ID. This study was done by Chang et al. (2014), and they were able to tests on two individuals with ID in ten 3 minutes session over five days. They concluded that the intervention had a positive effect on increasing physical activity. Their methodology and design have many similarities to this project, such as using an ergometer bike, and an entertainment system giving the rewards.

In a wrap up of the review; almost all the studies, regardless of the objective, had a positive experience doing the intervention with a form of exergame and either developmental disabilities, ASD or ID. In most of the studies, they lacked data to tell if the usage of exergame is likely to continue regularly. The review has proven that it is hard to find studies that involve intellectual disabilities and exergaming. If the inclusion criteria had been very strict on only to include studies involving exergaming related to ID and physical activity, with enough user testing, only one paper would have been the result.

2.4 Summary

This chapter provides basic knowledge about ID and exergames that is convenient to know when working on this project. Additionally, the chapter presents some aspects with psychological, behavioral theories that should be taken into consideration when designing the system. There is done a research on state-of-the-art solutions within exergames for individuals with ID, and research for bike related exergames. The investigation in state-of-the-art revealed that there are few exergame solutions on the market suitable for individuals with ID. Then a systematic literature review is done after intervention studies on ID and exergames. The systematic literature review showed that there are few studies that focus on increasing physical activity among individuals with ID with use of exergames. However, the few studies are mostly optimistic on doing such studies and recommend further investigation to get more data on the subject.

3 Methods and Materials

This chapter explains the methods and materials that were used to design and work on this project. The methods used aims to apply to the research paradigms in the task force committee report called “Computing as a discipline” by Comer et al. (Comer et al., 1989).

3.1 Structure

The report from Comer et al. (1989) mentions three paradigms that disciplines the computer science field: theory, abstraction (modelling) and design. Comer et al. focuses studies related to mathematics, but the paradigms translate well to a study such as this project as well. The theory paradigm should characterize the objects of the study, establish the relations between them, and evaluate if the relations hold. The abstraction paradigm should construct a model and make predictions and assess the them. The design paradigm should first state requirements, and specifications; so, do the design and implementation of the system; and last, test the system.

The work of this project conducts the following:

- Review of available products for bike exergaming on the market.
- Review of available activity apps that is customized for individuals with ID.
- Review of studies that does an intervention with intellectual disability and exergames.
- Interaction with user representatives such as experts, parents, and institution staff members.
- Research on important aspects with exergames, ID, and behavioral change, and the relation between these.
- Develop a paper prototype
- Receive feedback on the paper prototype from experts, parents and institutions staff members.
- Implementing a prototype of the system designed
- Analysis of design implemented and test results.

The preliminary reviews of this project are to establish the objects of the study, which is ID, exergames, physical activity, and behavioral change (motivation). In addition to the reviews, relevant studies on themes, and information from experts, parents, and institution staff members are included in characterization objects. With assessing the gathered theory, relations between the objects related to exergame usage for individuals with ID, the reason for having this project is accounted for. Also, findings from the relations between the objects are used in the devising of a system design. The paper prototype will be a model that is based on the theory gathered, which will be assessed by author, experts, parents, and staff members. When the paper prototype assessments have qualified its requirements and specifications, the prototype is implemented. The working implementation is tested in a realistic environment, which improves the quality of the product evaluation.

In practice, the development process is iterative, meaning requirements can be removed, added, or edited in later phases of the development. By applying to the participatory design(Muller, 2003), keeping a close user interaction, the requirements may be changed to meet the feedback received from users.

3.2 Data collection

3.2.1 Literature search

Knowledge about ID and physical activity was gathered in a theoretical and literature search before and during development. This search provided literature with information about the relation individuals ID have on physical activity and exergames. A systematic literature review was done to specifically investigate the usage of technology such as exergames and gamification to support physical activity among individuals with ID. The systematic literature review yielded studies focusing on intervention between ID and usage of some type of exergame. The found studies provided information on how to do such interventions, both in implementation and how to do test phases. This project will use the information from the found studies to learn from the results and get inspiration for research models.

3.2.2 Experts, seminars, and workshops

Much of the information on the user group has come from meetings with experts that have been working with individuals with ID. This information was exchanged on meetings and contact through emails in the start phase of the project, but also during implementation to discuss features and decisions. The most prominent expert was Audny Anke, professor at the University Hospital of Tromsø, who is used to working with individuals with ID and have experience in that field. Also contributing valuable information as an expert was Henriette Michalsen, who is the psychologist working with a Ph.D. on using E-health to support individuals with ID to be physically active. She has been gathering info from parents of individuals with ID and staff from institutions that aids this user group. The cooperation with these experts has provided valuable information on setting the requirements to a system for this type of users when it comes to design, content, and layout.

In cooperation with the Ph.D. project, it was arranged meetings with a reference group for the overall project. The reference group consists of volunteers that have experience with individuals with ID, and at this meeting, there were parents and institution staff members. The ideas for this project and paper prototype were presented at this meeting with illustrations of the design and information from the author. The attendants of the meeting were then allowed to give their opinion on what they thought about the ideas. The meeting resulted in constructive input to the project and new exciting features that could be included in the application. It was also motivating to see that the user representants were positive and interested in the project.

The project was presented at a seminar called *Physical activity with E-health support in individuals with intellectual disability* to gain more knowledge of research within the field. The seminar contained presentations from different projects and research relevant to ID and physical activity. The presentations found relevant at the seminar is shortly summarized in Appendix 2 in a table. Some of the critical remarks were that e-health should provide amusement, be a tool that can show others the achievements performed and provide rewards that are related to the performance in an activity. An e-health tool should be easy to use, but not childish as it can appear stereotypical and insult some users.

The ideas and plan for this project were presented at the seminar, and the audience could give feedback. As the audience consisted of many experts and experienced researchers, like presenters mentioned in the table in Appendix 2, the feedback was of excellent quality. The commenters were positive and thought that this project was relevant to the topic of the seminar.

The project was also presented at a workshop for projects related to medical informatics at the Department of Computer Science – The Arctic University of Norway (UiT), together with the Norwegian Centre for eHealth research (NSE), University Hospital of North Norway and Faculty of Health- and Sport Sciences, University of Agder. Among the participants on the workshop was Hervè Pinguad, a professor at Connected Health Lab, ISIS Engineering School INU Champollion Castres in France. He had experience with eHealth project for typically developed people and came with, among other comments, a suggestion that the user could get feedback on how he/she had performed. A description of what that was good and what that could be improved. Although this could be interesting for some individuals with ID, according to the experts, most of them will not care about their sport-related performance. Other suggestions from the audience were to use virtual reality goggles instead of a tablet or iPad, but individuals with ID is not likely to be comfortable wearing such equipment the experts have told.

3.3 Materials

3.3.1 Development platform

The application development was initially done in Android Studio, a platform to make applications for the Android operating system[7]. The reason for first choosing Android native was that compatible devices are more often cheaper to buy. Also, using the native development environment would make it easier to access device service such as Bluetooth connection. The Unity game engine was chosen as the development platform when the design process had gone further, and it was more evident how the product should be. Unity was preferred over Android native as it is better for creating virtual effects such as a virtual world or animations. A prewritten script bought online was used to simplify the Bluetooth service management (Shatalmic_llc, 2018). Another advantage of using Unity is that it can compile to both Android and IOS devices. The code performing the functionality of the application was written in C#.

3.3.2 Equipment

Control unit

The project has a tablet and an iPad available for running the application in a real-life setting. The tablet is a Samsung Galaxy Tab A 10.1, which is an ordinary tablet except for that it supports Ant+

[7] https://developer.android.com

connectivity. The reason for choosing this tablet was that some of the bike sensors that were planned to use only had Ant+ connectivity. The iPad is an Apple iPad Pro 10.5. This iPad was bought since we learned from the meeting with parents and caretakers that using an iPad were more common than using a tablet among the user group. The application should be tested on the iPad as well to know that this option can be supported. By supporting both platforms, it is likely that a potential user possesses a compatible device and avoids the costs of buying one. The app will also be possible to run on smart-phone, but the screen size will be little to watch the entertainment and visual effects.

Bike equipment

In this system, there is planned two solutions for measuring activity on an indoor bike. The first solution uses a regular outdoor bike mounted on a roller stative that keeps the bike steady and has a resistance on the power wheel without moving. The second solution as an alternative uses an ergometer bike of any type mounted with a cadence sensor on the pedal.

Figure 8 Tacx Smart Flow trainer, suits bikes with power wheels that have a size between 26" to 30".

In the first solution, a Tacx Flow Smart trainer (Figure 8) that support Bluetooth Low Energy and Ant+ connection. This trainer measures speed, cadence, and resistance; and it is possible to adjust the resistance on the power wheel. A cadence is a standard unit of measurement for bike trainers, and it means the frequency of the pedal turns when cycling. This trainer suits most type of bikes with a power wheel with a size between 26” and 30”. For testing of the first solution during development, we borrowed a three-wheel bike from Nav, a welfare institution in Norway that provide equipment for those who have special needs[8]. What is noticeable with using a three-wheel bike is that it will appear steady and stable to ride (Figure 7).

Figure 9 Tacx Smart Flow trainer with three-wheel bike and tablet on the handlebar.

For the second solution, we have bought an ergometer bike, U.N.O. Fitness ET1000[9], which is relatively cheap and straightforward (Figure 11). In this solution, a sensor is mounted on the bike crank to register the cycling activity and transfer it to the control unit. The bike's embedded sensors' measurements were not easily available for extraction, which was one reason for not using them. Using a separate sensor makes the system less dependent on the type of ergometer bike, and if anyone

[8] https://nav.no
[9] https://www.fitshop.no

has an ergometer bike at home or in the institution already, they would only need to mount it with a small sensor to use this system.

Figure 10 The Wahoo cadence sensor.

Several optional bike sensors were available on the market. We tried out Garmin Cadence Sensor[10] and Wahoo cadence sensor[11] (Figure 10). The Wahoo sensor turned out to be the better choice as the Garmin sensor only supported connectivity through Ant+ wireless technology. Ant+ is supposed to be a simple connection method and us commonly used in small sport-activity sensors[12]. Ant+ is not so commonly supported in new devices as you do not find it in iPads and the newest tablet we found that support Ant+ is from 2016. The Wahoo cadence sensor supported Bluetooth Low Energy (BLE) connectivity in addition to Ant+. BLE was launched in 2010 through Bluetooth 4.0 and is supported by most iPads and tablets produced after 2012[13]. Since BLE is more available than Ant+, the Wahoo sensor was chosen instead of the Garmin sensor (SIG, 2019). The Wahoo sensor uses the FTMS

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[10] https://buy.garmin.com/nb-NO/NO/p/pn/010-12104-00
[11] https://eu.wahoofitness.com
[12] https://thisisant.com
[13] https://www.bluetooth.com/about-us/our-history

protocol through BLE, the same as the Tacx Smart Flow trainer, which makes the connection implementation simpler as it can be used in both solutions.

Figure 11 Ergometer bike solution.

Costs of equipment

Table 3 An overview of costs for the equipment used in this system prototype.

Product	**Price**
Wahoo Cadence sensor	399NOK/ ~45USD (bikeshop.no)
Tacx Smart Flow trainer	2999NOK/ ~341USD (xxl.no)
Apple iPad Pro 10.5	7490NOK/ ~852USD (elkjop.no)
Samsung Galaxy Tab A 10.1	1989NOK/ ~227USD (komplett.no)
U.N.O. Fitness ET1000	2235NOK/ ~254USD (fitshop.no)
Three-wheel bike	Borrowed for free from Hjelpemiddelsentralen (nav.no)

Bluetooth Low Energy

Bluetooth Low Energy (BLE) is a low power consuming connection service that is well suited for devices with limited energy access and does not need large data package transferring. BLE uses a short-burst wireless connection with multiple topologies such as point-to-point (P2P) for one-to-one communication. The low power consumption makes the technology well suited for fitness trackers and health monitors (SIG, 2019).

FTMS protocol

A service made to export training-related data from fitness and sports devices, which allows a server to send measurement data to a client (Sports and Fitness Working Group, 2017). In this project, the Tacx Smart Flow trainer and Wahoo Cadence sensor will function as the server and the application running on a tablet or an iPad will be the client.

3.4 Development organization

3.4.1 Design

The paper prototype was made by making design drafts from the requirements and specifications that were established throughout the project. The drafts were made with the software Balsamiq[14], which makes it easier to draw app elements such as buttons, text boxes, and status bars.

A flow chart of the game design was made to organize the features that derive from the requirements and specification. The flow-chart of the application provides a structured overview that makes it simpler to implement the different parts during development. The flow-chart is shown in Figure 19.

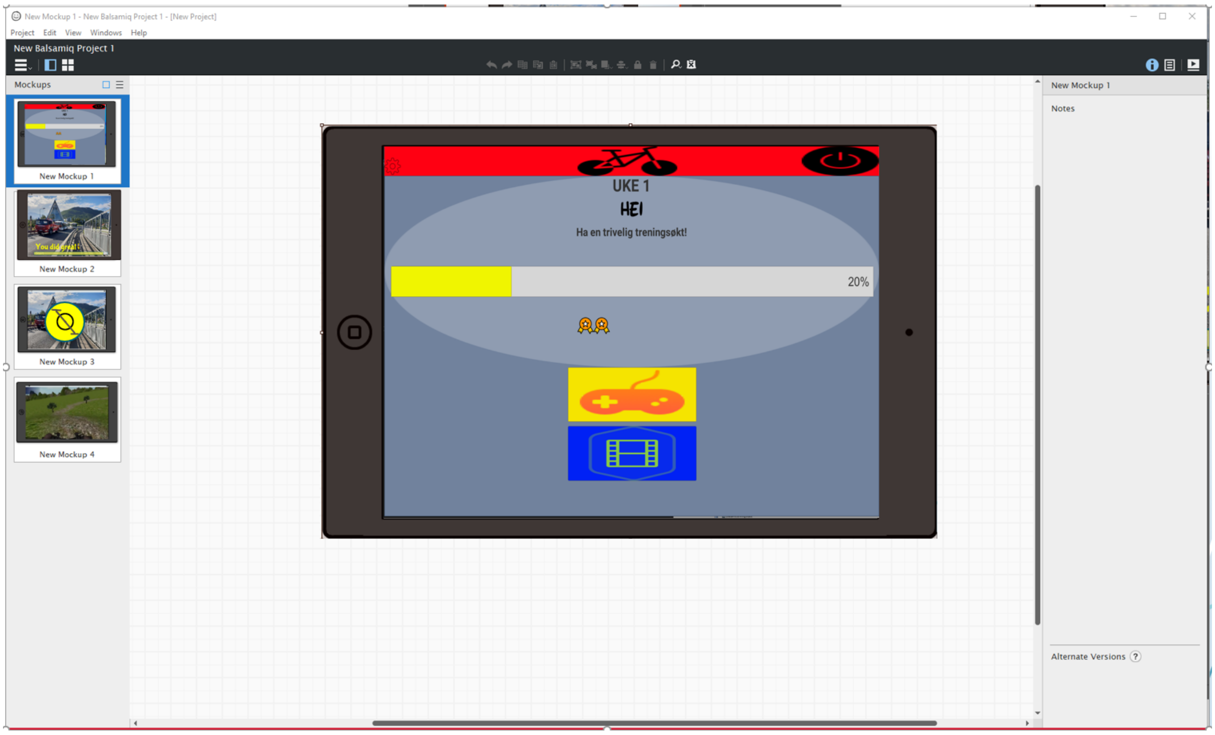

Figure 12 Balsamiq was used when making paper prototypes of the app design.

3.4.2 Testing

During development, each feature will be tested after its implementation and verified that it is working or not. When bugs and anomalies are found, they will be improved before they are tested again. When the development is considered finished, the app will also be tested.

Testing with expert

The product made in this project is usability tested to see how usable the application is for individuals with ID. In one of the usability tests, an expert can try the system and use its features. The expert then

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[14] https://balsamiq.com

gave feedback on how the system functioned and an assessment of how it will do for individuals with ID.

Figure 13 From usability test with an expert.

Testing at a daycare institution

The system was tested at *Tindfoten dagtilbud (Tromsø_kommune, 2018)*, a daycare institution that arranges different activities for individuals with ID. The testing at the daycare institution was a cooperation with the accountable for the project "Effects of physical activity with e-health support in individuals with intellectual disabilities," who set up the contact with the center. There was a meeting with one of the leaders, where this project was presented, and it was laid a plan on how the testing should be set up. Three of the visitors at the daycare institution tested the system in sessions spread out on four days, guided by the staff. One of the members in the staff was the contact point for receiving information on how to operate the system and whom to contact if there was any problem. This staff member was also responsible for providing information on how the tests had gone in an interview afterward.

The interview is inspired by the ISO 9241-11 standard for evaluating usability that should cover effectiveness, efficiency, and satisfaction. The interview questions about satisfaction were inspired by the System Usability Scale (SUS) (Brooke, 1996). To get an indication on effectiveness and efficiency, there were questions about estimated time usage on tasks and occurrences of errors during tasks. In addition to the SUS scale, the questions asked about the users' technical experience; features missed; and about other noticeable aspects. The interview questions used are shown in Appendix 5.

SUS is a ten-item scale that is developed to be an efficient way to measure industrial usability evaluation. The items constitute a statement of the users' opinion of the system, where the response indicates the degree of agreement or disagreement with a statement on a five-point scale (Brooke, 1996). The statements on the scale are set up such that the half of them would commonly lead to a strong agreement and the other half strong disagreement. The reason for having both positive and negative statements, altering each step, is that it prevents a biased response caused by that the user not having to think about each of the statements (Brooke, 1996). The study «A Comparison of Questionnaires for Assessing Website Usability» (Tullis and Stetson, 2004) compared several questionnaires and concluded that the SUS scale is giving reliable results, despite that it is plain and simple.

Figure 14 The three-wheel bike placed in the activity room at the day-care institution.

Presentation for the reference group

After the testing at the day-care institution, the system was present to the reference group in a meeting. The attendants of this meeting were the same as last time when the system designs had been presented for them. A live demonstration was done with the app running on a monitor, and the author going through all the features of the system. Afterward, there was a discussion of the system, and then the attendants answered a SUS scale about the system.

3.5 Critique of methods used

The systematic literature review did not include Google Scholar and a regular Google search, and it may not cover all relevant studies. Because of the short range of synonyms for types of ID and exergames in the search keys, the systematic literature review might miss relevant articles. The search for exergame apps for individuals with ID was limited to the two leading app providers, and apps available elsewhere is therefore not found.

Short trials of the system for testing will only give brief indications on how the application could function for a more extended period. The enthusiasm shown during testing can come from that the concept is all new and exciting, but over time the enthusiasm might wear off. Research shows that it may take up to six months to make a habit of new behavior, such as using this application (Prochaska and Diclemente, 1982). Therefore, an extensive test should have lasted 3-6 months where a suitable user with ID makes use of the system in a realistic environment, e.g., at home or in an institution.

3.6 Summary

The source of background information was gathered from experts that have cooperated with the project and through a literature review on intervention studies for ID and exergaming. Having presentations of the project on seminars and workshops gave valuable feedback to bring in the development process. The application is developed with Unity Game Engine since it is convenient to make such type of an app and it supports cross-platform compilation. The system can be installed with a Tacx Smart Flow trainer, a regular bike or with an ergometer bike of any type and a Wahoo Cadence sensor. Then the application can be used on a tablet, iPad or smart-phone with either of the two solutions. Testing was conducted with fellow students and short trials for a few individuals with ID.

4 Requirements Specification

This chapter describes the functional and non-functional requirements for the project. The presentation method of the requirements is inspired by the Volere Requirements Specification(Robertson and Robertson, 2013). The source for composing these requirements come from the meeting with parents and staff members; interview with parents and staff members; discussion with experts; and other sources such as seminars and studies. Also, by assessing the information gathered, requirements were elaborated by the author as well.

4.1 Organization

The interview with the parents and staff members (IPSM) was conducted by Ph.D. candidate Henriette Michalsen. She has presented the result at the seminar; *Physical activity with E-health support in individuals with intellectual disability* mentioned in the previous chapter and at workshops where the author addended. The result of this interview is the source for many of the initial requirements and is referred to as *IPSM* in Table 4, displaying all requirements. The reason for using an interview with parents and staff members as a source is that it is difficult to get practical information from the individuals with ID themselves. Parents that have a child with a type of ID and staff members that work at institutions where individuals with ID lives, is assumed to have the experience to give qualified information.

Individuals with ID often require support and guidance from parents or staff members when doing activities. It is expected that when using this system, parents and staff members will have to provide guidance and support for the user to tell him how to use it and motivate for using it. Therefore, also to know the individuals with ID well, the opinion of the staff members and parents should have a significant impact on the requirements.

Requirements are qualities that a system must have or a quality that the system must do. Functional requirements are the things that a system must be able to perform and come from the fundamental purpose of the system (Robertson and Robertson, 2013). Non-functional requirements are qualities and properties that the system must have, such as usability and performance, along with others (Robertson and Robertson, 2013).

Two short scenarios were made up to illustrate use cases for the project's system. The system product of this project is in these scenarios called MoviCycle to be easier to refer to it.

4.2 Scenario 1

Per is a 17-year-old adolescent with down syndrome who lives with his parents. Per is not very fond of being active and would instead like to lay on the couch watching Mr. Bean on his iPad. Per knows how to find the Mr. Bean video clips on YouTube as he has been using this application for a long time. When it is summer, and the weather is beautiful Per likes to go biking with a three-wheel bike in the park, but when it is winter or bad weather, this is no fun. Per's parents would like him to be more active even when it is winter or bad weather, so they have obtained MoviCycle and installed the app on the iPad. To start using it the parents had to use some time with Per convincing him that it is a good idea, but now Per is using the bike in 10 minutes sessions three days a week. The MoviCycle system helps Per to achieve 30 minutes of 150 minutes with activity per week, that is recommended from the health department. When Per uses MoviCycle, he likes to watch Mr. Bean and SpongeBob episodes.

4.3 Scenario 2

Line is an 18-year-old adolescent that have autism and lives with her at an institution for people that have disabilities. At summer Line often enjoys a trip outside with her bike, but in the winter biking outside is not recommended for her. The institution that she lives in has gotten the MoviCycle system, and Line uses this equipment a few times a week. When Line cycles on MoviCycle she enjoys watching videos from family trips that she has been on and listening to her favorite song.

4.4 Functional Requirements

This section presents the functional requirements of the application.

Table 4 Requirements specification, (IPSM = interview with parents and staff members)

Nr.	Description	Source	Fit Criterion
1	The system should show progression in activity visually.	IPSM: "Focus on that all movements are activity – show usage of energy visually.", "Make things simple, put in a system, help to visualize activity.", "Enjoys getting attention and praise for achievements done."	Show that cycling is an activity, be able to show others activity achieved.
2	The system shall excessively use symbols to describe navigation and actions.	IPSM: "Only a few know how to read," "Used to point at symbols or things for expressing themselves."	A user should not be required to read to be able to use the system.
3	The system shall show visually when a session begins and when it will end.	IPSM: "When activities are predictable, it is easier for the user to enjoy them."	A user should be able to predict how long a cycling session will last.
4	Using the system shall motivate to continue cycling with the use of fun, surprising animation throughout the session.	IPSM: "To be in activity is rarely motivating by itself.", "Must be something more that brings amusement to the activity."	A user should be entertained by the visual effects in the application.
5	The system shall be runnable on a tablet or an iPad.	It was said on the meeting with the parents and caretakers that the individuals with ID they are related to are used to using a tablet or an iPad.	A user should be able to run the application on a tablet or an iPad.
6	Any text displayed shall be either Norwegian or English	The group that is in contact with the project and that are potential users are all Norwegian. To be able to spread the idea further, support for English will extend the potential for users.	A user that understands Norwegian or English should be able to read and understand any text in the application.

7	The system shall support the use of a Tacx Smart Flow trainer or similar that can be mounted with a regular bike.	It was learned at the meeting with parents and caretakers that many of the individuals with ID enjoy biking outside when the weather allows so.	A user should be able to use the same bike that she or he uses outside.
8	The system shall be able to use any ergometer bike that can be mounted with a cadence sensor.	Some households own an ergometer bike and would save space by not having to install another type.	A user should be able to use the system on an ergometer bike.
9	The system shall play videos of tracks through a landscape or familiar paths/streets when pedaling.	IPSM: "To be in activity is rarely motivating by itself.", "Must be something more that brings amusement to the activity."	A user should be able to play a video of a track/ride by pedaling on the bike.
10	The resistance on the paddling shall be adjusted after the current steepness of landscape in a video.	Learned at the meeting with parents and caretakers with making the system more like biking outside it can be used to learn how to use a bike.	A user should feel that it is heavier to cycle up a hill than down.
11	The system shall play music when pedaling.	IPSM: Many of the individuals with ID enjoys listening to music.	A user should be able to play the music that he or she likes while pedaling.
12	The system shall play videos that are entertaining when pedaling.	Learned at meeting with parents and caretakers. The individuals with ID often like to watch a specific movie or tv-show repeatedly.	A user should be able to play an entertainment video by pedaling.
13	The system shall provide different lengths of exercise sessions.	IPSM: The experience with cycling varies; some may be able to cycle for 20 minutes while others have had enough after 10 minutes of cycling.	A user should be able to choose the length of the exercise session.
14	The system shall have a game where stars and medals are collected in a virtual world by pedaling.	IPSM: "To be in activity is rarely motivating by itself.", "Must be something more that brings amusement to the activity."	A user should be able to control a unit in a virtual world collecting stars and medals by pedaling.
15	The system shall have a game where garbage is collected of the ground in a virtual world by pedaling.	Learned at the meeting with parents and caretakers that the game could beneficial be educational to learn that garbage should not lay around.	A user should be able to pick up garbage in a virtual world with pedaling.
16	The system shall have a game where letters are collected to spell a specific word in a virtual world by pedaling.	Learned at the meetings with parents and caretakers that they would like a game that can educate how to spell words.	A user should be able to collect letters that make up a word by pedaling.
17	The system shall have a way of setting the goal activity time and show the progression of achieving this time.	IPSM: "Focus on that all movements are activity – show usage of energy visually.", "Make things simple, put in a system, help to visualize	A user should be able to set a goal time to achieve and see how far he or she has come on this goal.

		activity.", "Enjoys getting attention and praise for achievements done."	
18	The system shall have a game where a unit is controlled in a virtual world, and a friend can control a unit with another instance of the system in the same virtual world.	IPSM: Some of the individuals with ID likes to be social while doing activities.	A user should be able to control a unit in a virtual world and to see another user represented by a unit in the same virtual world.
20	The system shall store activity that has been performed and has a way to display the history.	IPSM: Parents and caretakers would like an overview of the activity that has been done.	A user should be able to look at an overview of earlier conducted activity sessions.
21	The system shall allow the user to choose the entertainment video.	IPSM: There is a high diversity among individuals with ID in what type of entertainment they like.	A user should be able to choose a video he or she likes for a training session.

4.5 Non-functional requirements

This section presents the non-functional requirements.

22	The system shall not require special competence in the technology used to set up the system.	Learned at meeting with parents and caretakers that the parents and caretakers that help the individuals with using the system are rarely experts in technology.	A user should be able to set up the system without having special abilities in technology.
23	The system shall not require extensive knowledge about exercising for using it.	IPSM: "Activities should be easy and simple to do," "individuals with ID are often in bad shape."	A user should be able to use the system without being in good shape.
24	The system shall not make it to sophisticated and advanced to do a session, but also not too childish.	IPSM: "All welfare technology support must be simple and require little resources.". Some of the individuals with ID have learned to look up videos on YouTube by using it for an extended period. Likes to be viewed as a regular or cool person and not as a child.	A user should be able to use the system after 20 times using it and should not be embarrassed by a simple UI.

4.6 Summary

The requirements are the results of an iterative process of altering the initial requirements derived from the preliminary theory research. In the process, requirements at different interactions have been presented as paper prototypes to experts and institution staff. The feedback on the prototype was used to assess the requirements and tell if they were sufficient to fulfill the goals of this project.

5 Design

This chapter presents the design of the application, starting with some preliminary designs before going through the final prototype design. The purpose is that this design will fulfill the requirements set in the previous chapter.

5.1 Data application

5.1.1 Design process

In the introduction, it was mentioned that gamification of the stationary bike-cycling should take advantage of that individual with ID often likes to watch videos and movies. It was learned from experts that these videos often were watched on YouTube or TV and that it could be the same content used repeatedly. It was also learned that individuals with ID often likes to play video games on tablets or iPads, and it was potential in using this to make them interested in physical activity. These ideas were used to create the requirements, which was used to elaborate on several potential designs. The different design ideas have been receiving feedback from experts, and parent focus-group, which was weighted heavily. The feedback received often lead to new requirements of changes in some of the existing requirements. Then new designs had to be devised from the changes in the requirements.

Not used idea: "Entertainment bank"

In this idea, measured activity on a stationary bike should earn the user "video-time" proportionally to time used on cycling. The amount of video-time earned will then be saved in a data application, "entertainment bank," and can then be used whenever to gain access to watch videos or TV-shows. The user may watch videos or TV-shows for as long as there is video-time in the entertainment bank. The relation between activity time and video-time should be adjustable so it can be customized to individual preferences. One user may be happy with receiving 10 minutes of video-time for 10 minutes of activity time, while another user does not think that is enough reward for the effort in physical activity and requires two times the activity time in video-time.

The reason for not using this design in the final solution was decided in discussion with parent-group and experts. It was considered a too abstract reward to save up video-time for engagement in physical activity. It obscures the relation between physical activity and gained reward when they happen at different points in time. First, the activity is performed, and then the reward is received afterward or even after an extended period. The experts said that individuals with ID often struggle to understand abstract concepts such as money, which a bit like this entertainment bank solution.

It was also said that if such a system is to be effective, the users access to videos or TV-shows must be controlled; otherwise, they could watch a video without using the bike. If a user that is used to have free access to watch videos and TV-shows, taking it away may be viewed as a punishment. To use punishment as a motivation for the user with ID to be in physical activity was not recommended by an expert in motivation theories. The user is likely to get a negative association to being physically active and will eventually protest to take part in such a situation.

Not used idea: Modify open-source video game "Supertuxkart"

Supertuxkart is an open-source 3D video-game built around racing with a variety of characters, tracks, and modes to play (SuperTuxKart_Team_©, 2016) (Figure 15). The game can be played against the computer or other players that run the other characters on the same track. The idea was to modify the game to be able to use the bike as the game controller. To go forward in the race, the user would have to pedal on the bike that would make the kart to have a speed proportionally to pedaling phase. It was planned to mount sensors on the steering such that turning the handlebar on the bike would steer the cart on the track.

Figure 15 Screenshot from a race in Supertuxcart.

This idea was not realized due to several reasons. It appeared that playing the game with the stationary bike would be difficult as the game is designed to be managed on computers or smart-phones. A YouTube video shows a project where this idea is realized. The video shows that it is hard to keep up with the competitive karts and that a user is likely to lose[15]. With modification, the game could have been made easier to give a fair chance to win it, but it would remove intensiveness and excitement from it. Also, it would require vast modification of the code base to this game, which also has many features that are likely to be too complex for an individual with ID to operate. The feedback from the parents was that this could be interesting, but they proposed to have a game with learning aspects instead. Because of the mentioned drawbacks, it was considered that to better meet the requirements it would be better to design a game from scratch.

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[15] YouTube video with an ergometer bike as game controller: https://www.youtube.com/watch?v=lmzmY1Aj3-k

Paper prototype

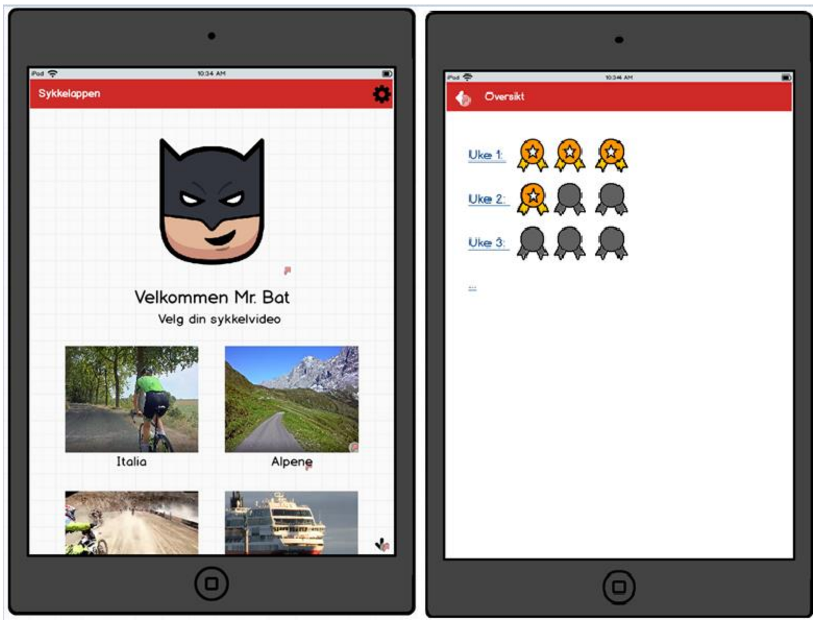

Figure 16 First design drafts of start page and activity log.

Figure 17 Design drafts from when starting video mode, and when a video mode session is finished.

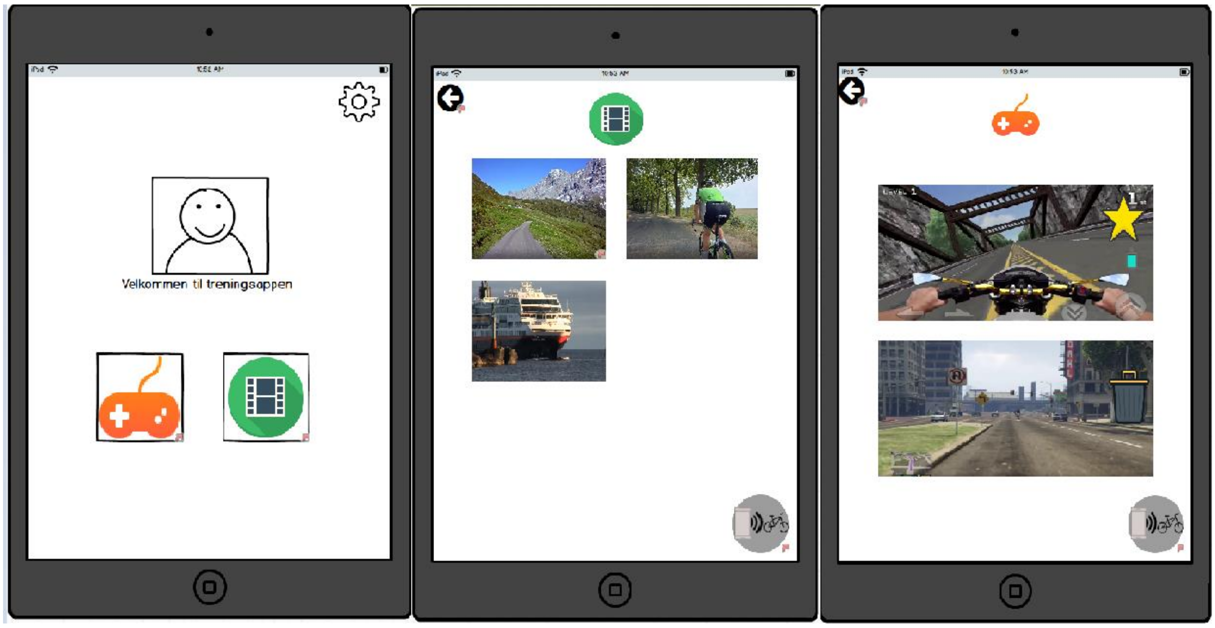

Figure 18 Design draft after adding game mode.

Figure 16 shows the first design draft of the application graphical user interface (GUI). This design was before the requirements concerning the game-mode option were added. When adding the game-mode option it appeared to be more useful to have navigation to the two modes on the first page than the list of videos Figure 18. When inside video mode the design would remain the same, as on the first drafts.

5.1.2 Final data-application design

The iterative process with receiving feedback on the paper prototypes lead to the final design that was implemented. It was made clear in the feedback that the rewards should be given instantaneously during an exercise session on the bike. This will make the connection between the reward and the exercise less abstract. The videos and the video-game should be available through an app that is designed for a tablet or an iPad. The app will receive training data from the bike sensors and then use them to control direct video playing or function as a game controller to a video game.

A design flow-chart is shown in Figure 19 describes how a set of features in the app is related. When the app starts, a display showing the status of the current week activity time performed. From the start page, there is a navigation option to settings, video mode, game mode and history of activity. Video mode and game mode are the two options for activity sessions. After an activity session is finished, the activity time is added to the total activity time of the current week.

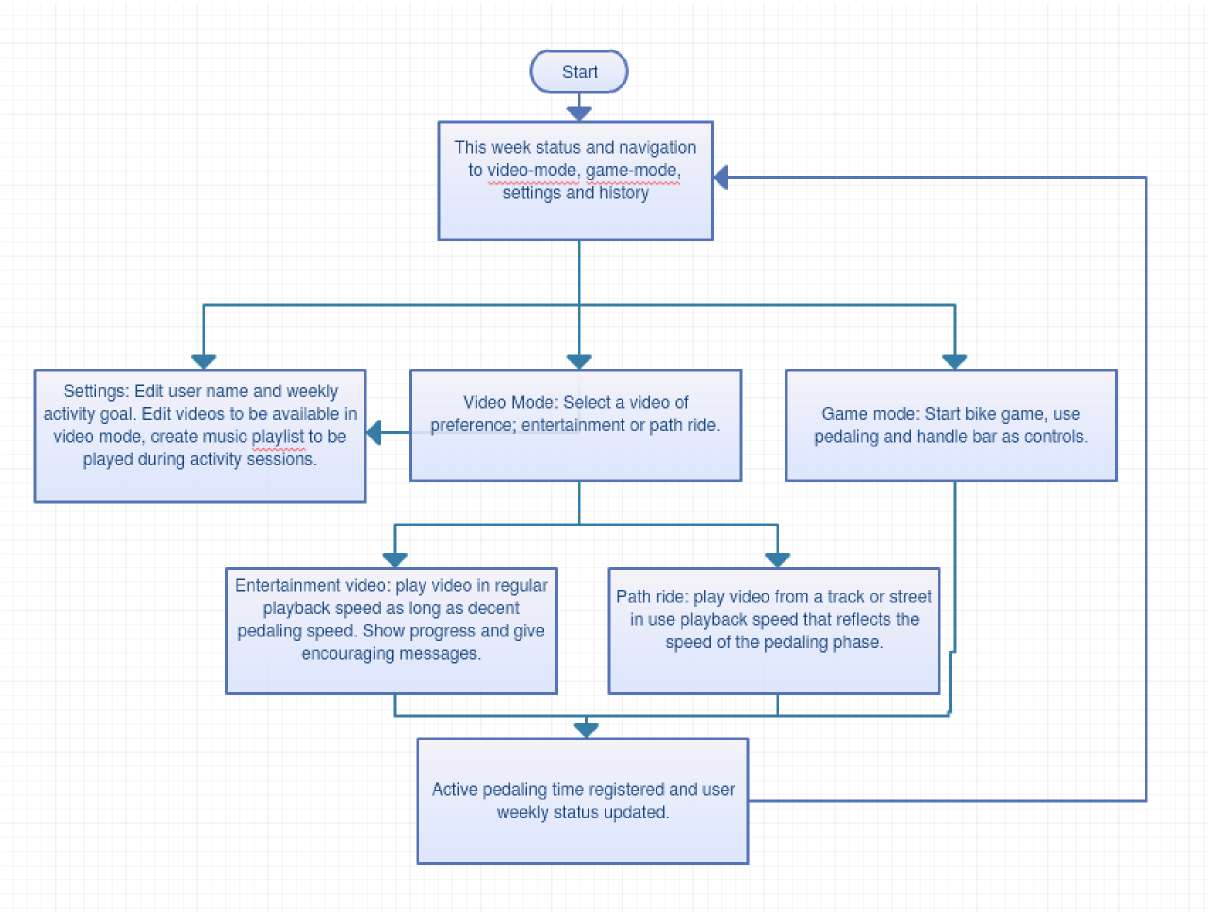

Figure 19 Design flow-chart over the app.

General design

The app uses a generally design for all views and functionalities, such as button positions, color composition, and navigation logic. Main event navigation buttons are placed in the body of the view; these are entering video or game mode and entering training activity log view. Navigation buttons placed in the top bar are for navigating to non-essential app features, such as entering settings and navigating backward. Text that is used to present information is short, simple, and have a direct style. The composition for the main colors in the app is red, blue, and yellow. All these design choices are there to apply to the requirements that demands usability towards individuals with ID.

The colors red, blue, and yellow are inspired by the book *Designers Guide to Color 4 (Shibukawa and Takahashi, 1990),* where it is recommended as a preferred color composition. The background color is grey in several of the views. Grey is a recommended background color as it is a conservative color that blends well other colors, good quality for a background (Jackson et al., 1994).

Start page

At the start page, the user is presented with the current week activity time achieved in the current week (Figure 20). The progress is shown in a progress bar and with that compares the achieved activity time with the target activity time for the week. The start display will also greet the user with a message that changes when the progress goes further. If the achieved activity time is 75 minutes and the target activity time for a week is 150 minutes, the display will show a half-full progress bar and a message telling you are half-way there to achieve your goal. There is also displayed medals for each daily goal that is achieved. A daily goal is set by partitioning the week goal by seven and is achieved when the current week activity time exceeds the partition.

It was decided to have the status of the activity performed on the front page as it could function as motivation for a user to fulfill the target time. Using progress bar and medals, along a motivating message are supposed to enhance this motivation to complete the target time.

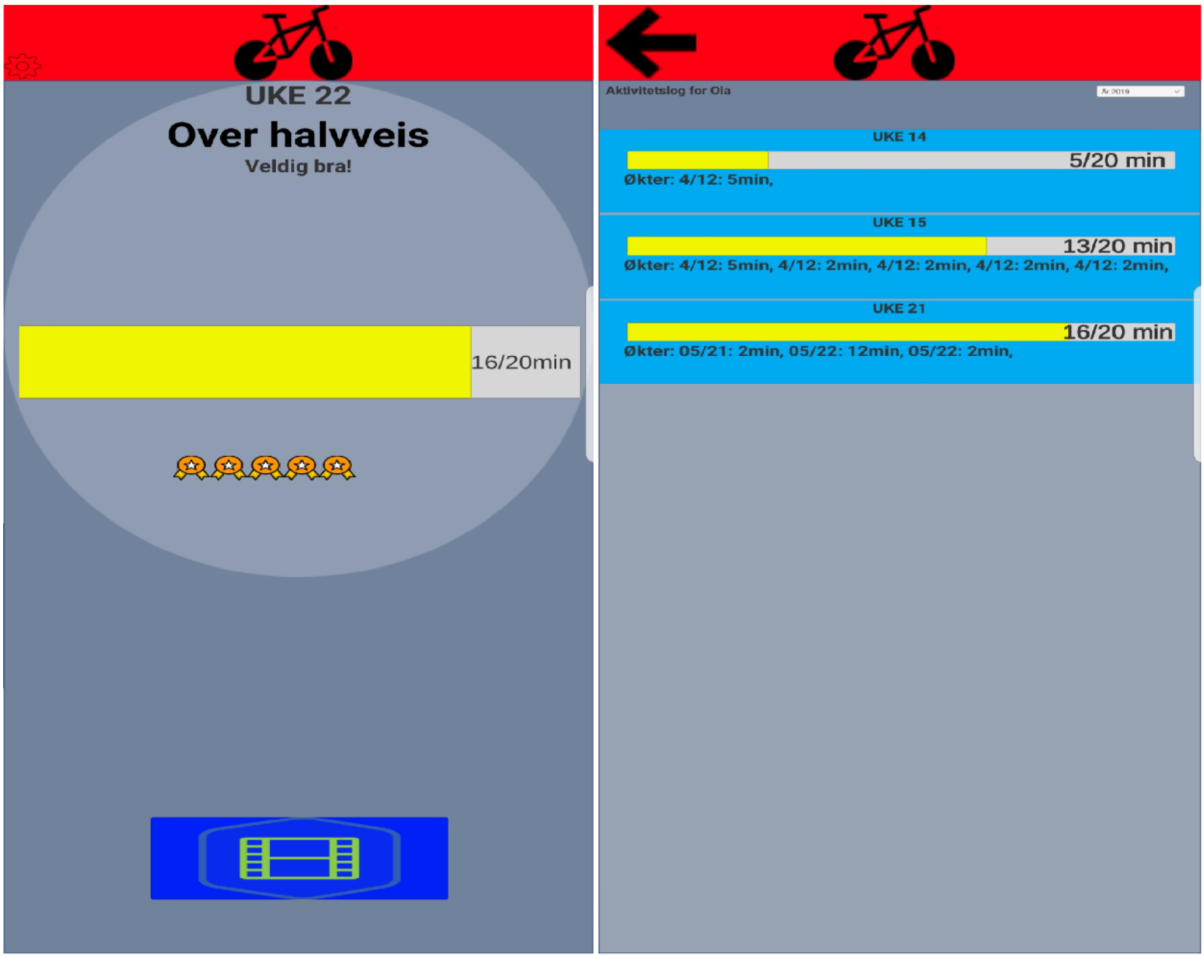

Figure 20 Left: Start page with week progress for the activity. Right: Activity log, accessed by tapping progress bar.

In the top bar to the left is the button to enter settings. The activity-log is reached by clicking on the progress bar or anywhere inside the oval circle around it. In the activity-log view, all weeks that the user has performed activity in is shown for a given year chosen in a dropdown menu. The weeks are displayed in boxes in an ascending order which can be scrolled through. In the boxes, the activity performed for this week is shown with a progress bar and minutes of activity the same way as at the start page. Then a more informative description is given with activity duration in minutes and what date it was (Figure 20).

Settings

The settings view allows the user to manage all the configuration that is possible in the app (Figure 21). Among the configuration is to set a user name and to choose a target time for cycling that should be performed in a week. The speed that is required to play entertainment videos is a setting option, such that it can adapt the user capabilities. A user that is in good physical shape can have a higher speed limit for playing videos than a user that has a worse physical shape. There is also possible to see what device is connected to the app and if there are other devices available.

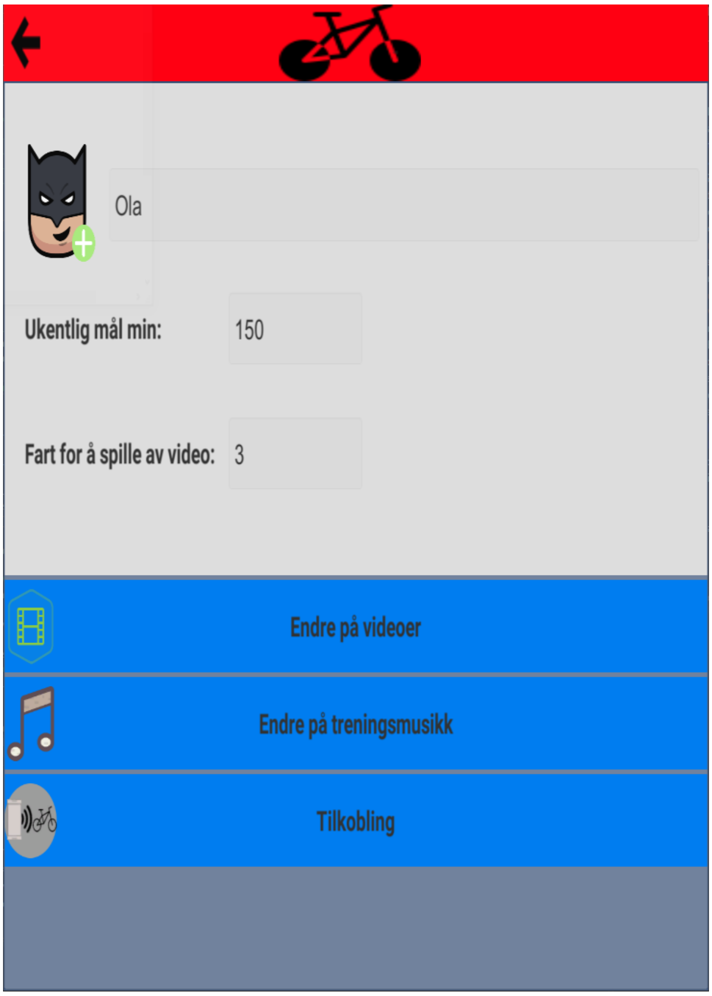

Figure 21 Settings view, set user name, adjust weekly activity goal and adjust speed required to play entertainment videos.

One can also edit the video list by adding and removing videos after what is preferred. The videos that remain on the list will be the options to choose from when entering video mode. There is possible to put together a playlist of music that one would like to listen to during activity sessions. The music that is selected will be played when using pathway videos or game mode for the activity session. The videos that one would like to add has to be available locally on the device. Deleting a video when editing the video list will not remove the video file. It is also the same for music that is to be added to the playlist of songs. The views for editing the video list and music playlist are shown in Figure 22.

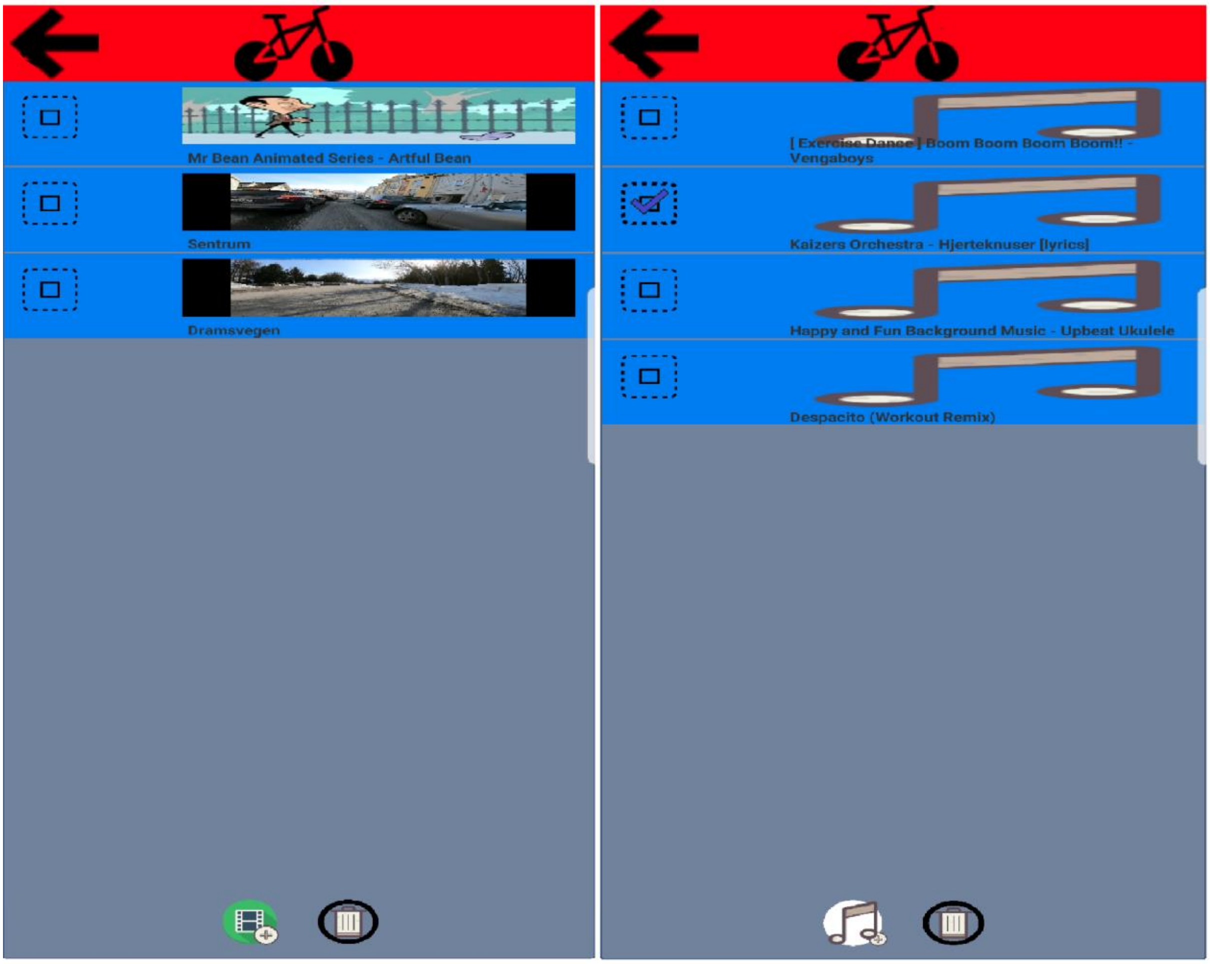

Figure 22 Left: Editing the video list, adding or deleting videos. Right: Editing of a playlist of music, selected songs will be on the list.

Video Mode

When entering video mode, one is presented with the video list that is put together in settings (Figure 23). A voice command tells the user that a video needs to be selected to continue to a training session. For each video in the list, one can see the name of the video and its length in minutes. There is also shown a thumbnail, a screenshot from a frame in the video, in the video list item. To select a video, one must click on its list item, and one is then taken to the video player.

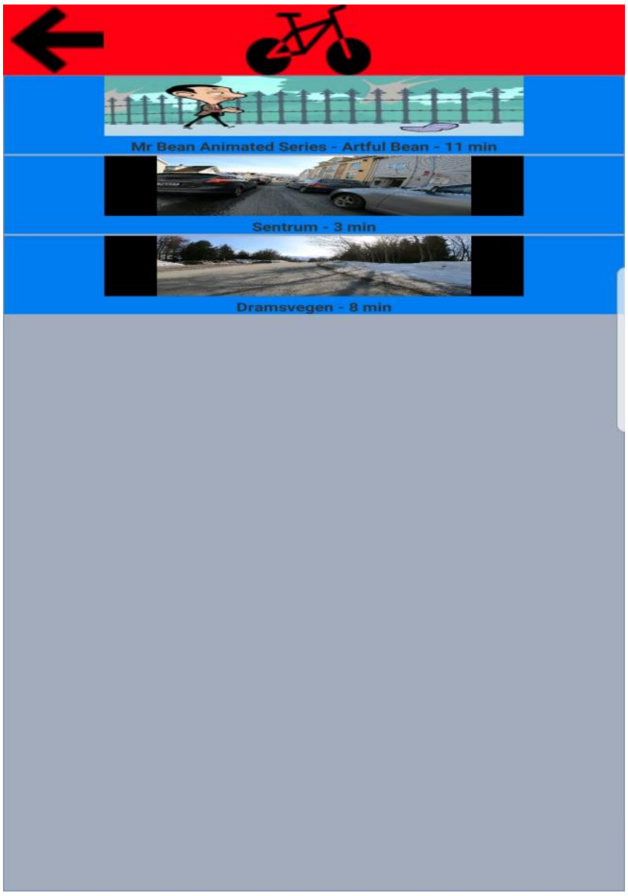

Figure 23 The list of videos that have been put together under settings. Tapping a video will initiate the playing of that video.

In the video player view, one is presented with an animation that illustrates that you should pedal. It is also described with text that to play the video, you must cycle on the bike (Figure 24) and a voice command telling the same. At the bottom of the screen is a progress bar that tells you how far you have gotten in the video and thereby also the activity session that is started. During the session, seven different messages will show, telling that the user is doing well and how far the session has lasted.

There are two types of videos that are managed differently, entertainment videos and pathway videos. An entertainment video can be a TV-Show, movie, cartoon or similar that the user likes to watch. A pathway video can be a video recorded at a bike trip following a path of some kind or a video from a roller-coaster ride. During pathway videos, the playlist configured in settings is played alongside.

For both types of video, the user must pedal to play it; otherwise, the video pauses. An entertainment video will be played in normal playback speed if the pedal activity yields a speed above 3 km/h and if the speed is below that, it will pause. A pathway video will be played with a playback speed relative to the yielded speed from the pedaling activity. When the pedal activity yields a low speed, the video playback speed will also be low and then increase when it yields a higher speed. The playing of the music playlist will also pause if there is no pedaling activity registered. The animation that illustrates that you should pedal will show when inactivity happens during a session. When the activity session is done, confetti effects and a trophy will be shown, and a cheering sound played (Figure 25).

The resistance for the cycling should adopt the terrain in the pathway videos. When there is an uphill, the resistance is increased, and when there is a downhill, the resistance will decrease. Initial resistance from where the adoption should start should be adjustable under settings to adopt the physical shape of a user. In addition, the aggressiveness on the resistance regulating after the terrain can be editable under settings to make sure that cycling uphill will not be too hard for a user. The adjusting of the resistance will only be available for the Tacx Smart Flow trainer, as the resistance adjustment on ergometer bikes is performed manually or through the embedded computer. A solution for ergometer bikes can be devised if the embedded computer allows third-party software to adjust the resistance through Bluetooth connection.

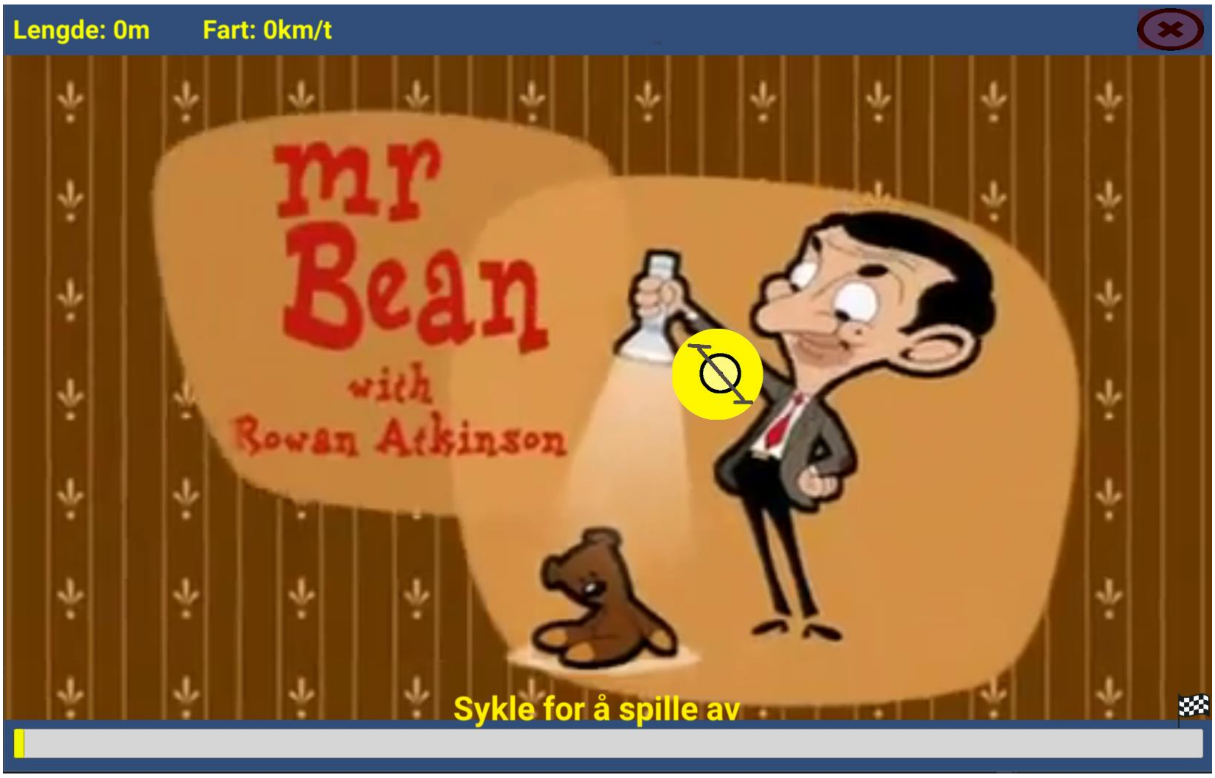

Figure 24 Video player mode before starting to pedal. Video is an entertainment video.

Figure 25 Pathway video at the end. Cheering audio sound is played, and a trophy displayed.

Game mode

This feature is not implemented because of a shortage of time, but its design has still been composed. This mode for an activity session should prompt the user with a virtual 3D world where it is possible to control a unit to go around. In the virtual world, there should be objects such as trees, houses, streets, and variable terrain with hills and pathways. There should be an option to choose between different types of virtual worlds, one with a countryside theme and one with a city theme. The unit that is controlled should be an avatar that chose to represent the user in this world, for instance, an animated person on a bike or small car. To make the unit move forward in the world, the user must pedal on the bike and change direction by steering with the handlebar.

In the virtual world, there should be items that can be collected by hitting them with the unit. These items can be stars and badges, that when hit, yields a cheering sound and increases the number of hits. When a certain number of hits is reached, the activity session can be considered complete. The number of hits to complete a session should be configurable to fit the differences in physical shape in the user group. The items to be collected should be optional to be shifted between medals and stars, to other items such as garbage or exciting figures.

To collect letters as the items should also be an option. The purpose of the game is then to collect letters that spell a specific word on a screen. When all the letters in a word are collected, the activity-session is considered done, and the user should be prompted with a cheering sound and confetti animation. The word that shall be spelled should be configurable, and it should be allowed to have several words that can be spelled.

As an option, the game should support multiplayer where it is possible to play with one or several friends. The user avatar will then be moving around in the same virtual world as a friend that has an installation of the system. The friend's avatar will then be displayed as it moves around. An illustration of the letter collection mode with a friend is shown in Figure 26.

Figure 26 Design draft of game mode with letter collection and a friend playing in the same virtual world.

Connection with sensors

The sensors register the pedaling activity and transmit to the app through Bluetooth. When the app starts, it will search for an available sensor that provides the services that are required and connect with it. If there are several sensors within reach of connection, it will choose the one that was used last time the app ran, or it can be selected under settings. When a sensor is connected, it will start transmitting data when a user cycle with the pedals on the bike. An estimated speed that the pedaling activity make is calculated from the data received. This speed is then used during sessions in video or game mode to register activity from the user.

Saving data

The app configuration and user data are saved at persistent storage when a session is completed and when the app is exited. Configuration data that are saved are the video list, music play-list, last used sensor devise and who the last user was. The user data saved are goal activity time for that week; activity sessions with length; the video used; and current date. When the app starts, the user data of the previous user using the app is loaded and displayed in the status view in the start page. The changing to another user and its data is done by changing the user name under settings.

5.2 Equipment

The roller trainer is mounted on the power wheel of the bike. The roller trainer must be adjusted such that the tire gets enough fraction with the roller wheel that does the measuring. A power supply socket must be within reach of the cable to the roller device. The tablet is mounted in a holder on the handlebar.

Figure 27A bike roller trainer before it is attached to the power wheel of the bike.

A set up with a stationary bike requires a significant space for most typical homes. When a home already owns an ergometer bike, it would be beneficial to be able to use this for the system to reduce space requirement. As it is likely that the bikes differ in design, it cannot be assumed that built-in monitoring sensors can be used. Therefore, external sensors that can be mounted on any type of stationary exercise bike shall be used.

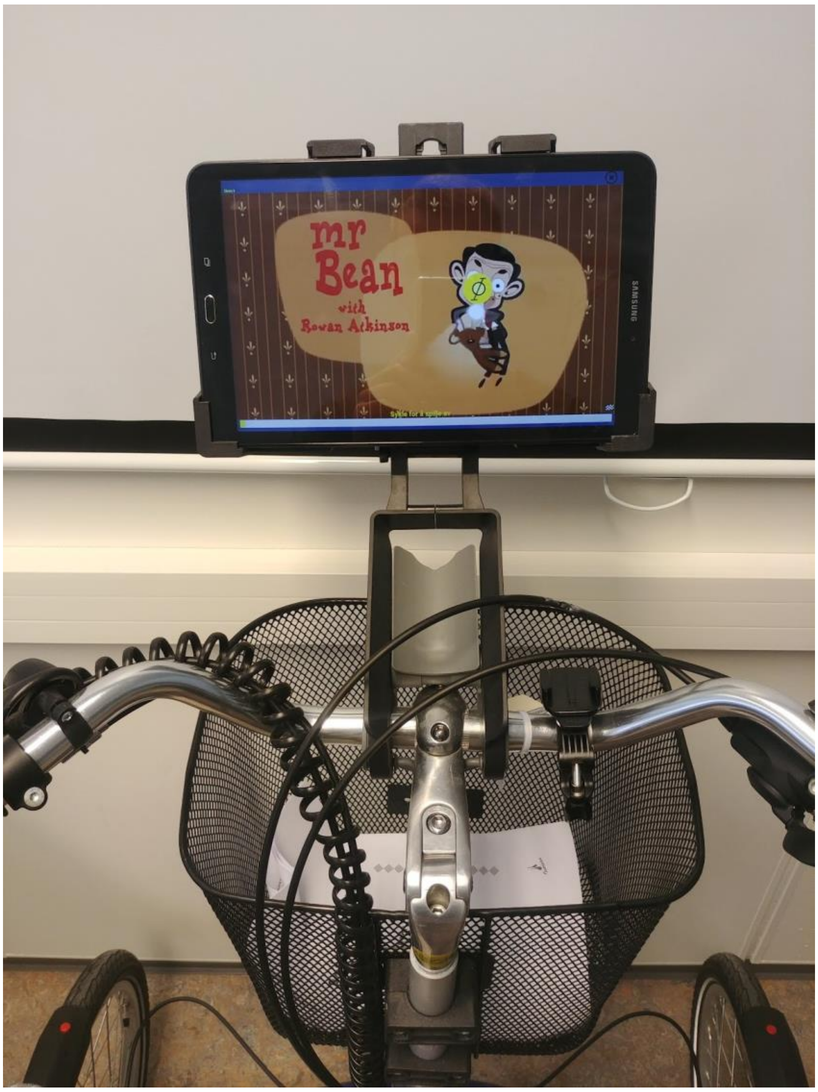

Figure 28 Tablet mounted in a holder on the handlebar.

In the solution with an ergometer bike, a cadence sensor is glued to one of the pedals. The sensor is mounted on the inside of the pedal, so it does not come in the way when pedaling movement (Figure 30). The tablet is placed on the handlebar or in a holder mounted on the handlebar where it is in clear sight of the user (Figure 29). Using a bigger screen is possible if the tablet supports screen mirroring and can transmit its screen view to a compatible receiver that can display on a monitor, e.g. TV or projector.

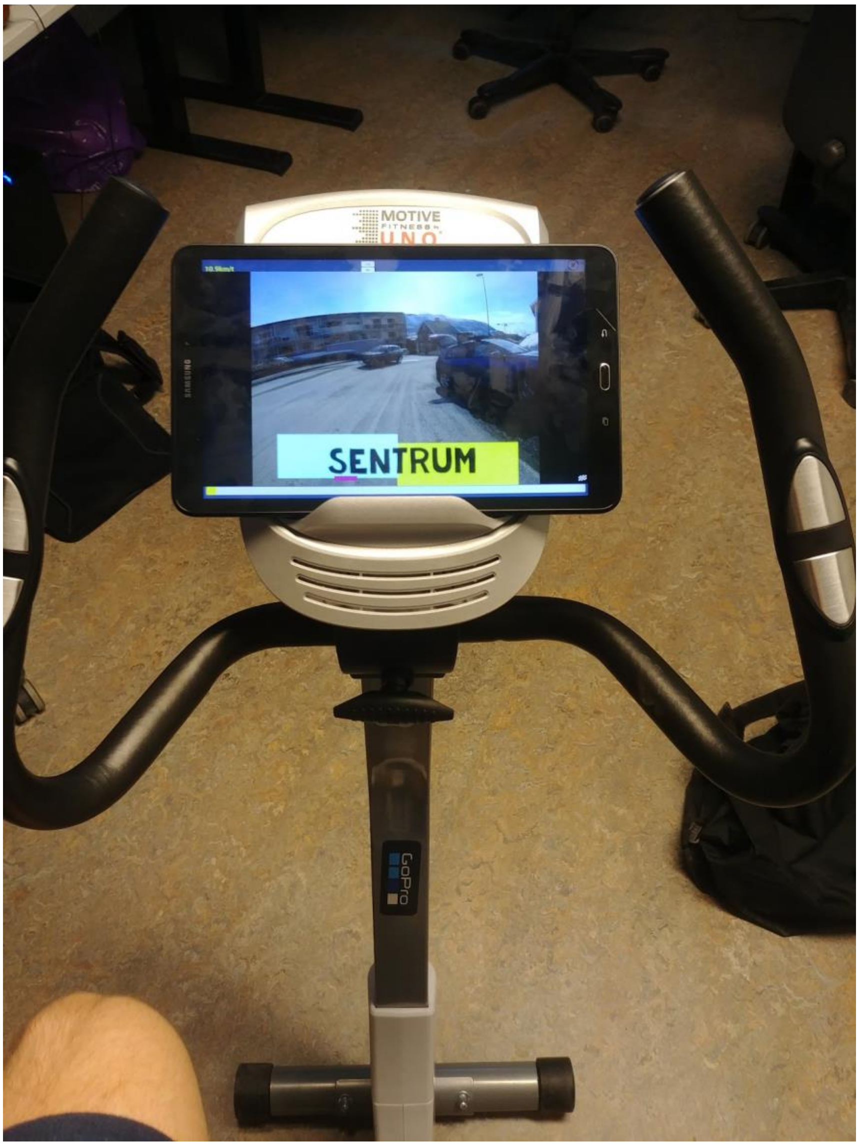

Figure 29 Tablet placed on handle bar of an ergometer bike.

Figure 30 Cadence sensor mounted on the crank of the ergometer bike.

5.3 Summary

This chapter describes the design for the final prototype solution. This design's purpose is to fulfill the requirements that are stated in the requirements chapter. The design consists of two parts, a software part, and a hardware part that is compliant with the software. The software module is an app that controls all the exergame elements, and the hardware set-up is the bikes and how they are mounted with sensors.

6 Implementation

In this chapter, it will be explained how the design has been implemented with details about the technology and how it was used.

6.1 Control unit

The app is made to be run on a tablet or an iPad. A smartphone could be an option for displaying the app, but a larger display will be better to show the visual effects in the app. The natural positioning for display on a bike is on the handlebar, which gives a distance from the display to user eyes that makes it preferable with a screen size above 10’’ (Starico, 2019). The ability of the device for sharing its screen to a TV through Google Chromecast (Google, 2019) will make it possible to view the content on an even larger display than a tablet or iPad. With the option to cast to a bigger screen, using a smartphone, such as shown in Figure 32, functions well.

Figure 31 The iPad in use on the ergometer bike.

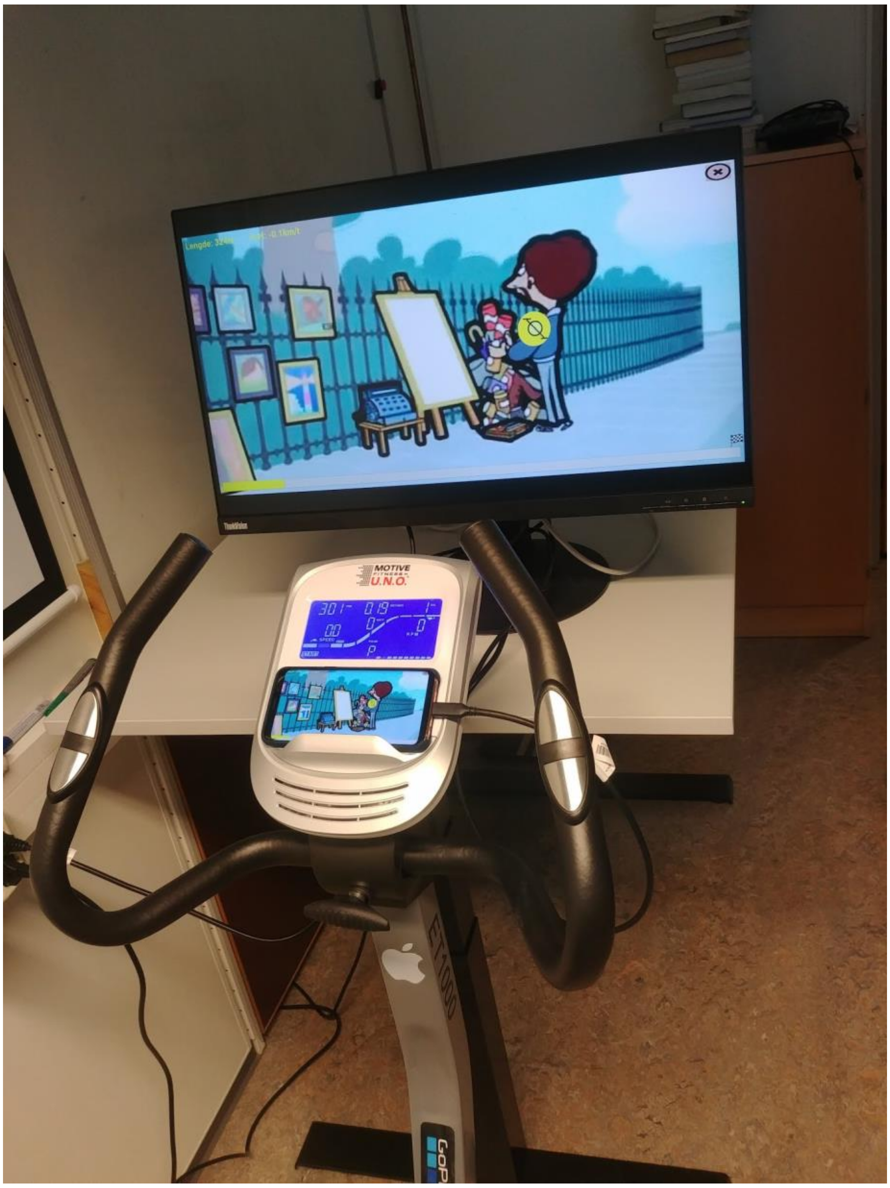

Figure 32 The app running on a smartphone mirroring the screen to a larger display.

6.2 Implementing the app

Initially, the app was implemented in Android Studio and would only be available on Android devices. The advantage of using a native platform for the development was that it would be easier to integrate with system services such as Bluetooth. However, the development was changed to Unity, as visual effects and game elements are easier to develop there, and it supports cross-platform compilation.

Developing in Unity

Unity Engine provides different approaches for game development. This platform supports both 3D and 2D mode for designing as an option. The project uses both modes in this app, which is allowed with Unity. The 2D design mode is used for navigation menus, status view, and displaying video mode option during an exercise session. The 3D design is required to create the game mode where one should be able to go about in a virtual world. As the game mode is not implemented, the current version of the app is only in 2D.

The design of the app is made in consideration for usage on a touchscreen. When designing for a touchscreen, all navigation and action that requires user input must be accessible through the display view. In the Unity engine, there is a design window to edit the design, and then the changes in the app can be viewed in a separate test display (Figure 33). When developing, the Unity Engine allows running the app in a test display to test it. After each adjustment to the design it was first tested in the test display, and if the result was dissatisfying, new adjustments were made and then a new test run. When a feature was running as preferred in the test display, the app was compiled to the tablet device to test on a realistic platform.

The Unity engine allows the app to be compiled to android tablets and iOS iPads. Because of the shortage of time, the app is not sufficiently tested on an iPad during development. When the app was compiled for iOS and tested on an iPad, it failed to receive data from the bike sensors through Bluetooth. Further development and testing on an iPad are required to make sure the app runs properly on an iOS iPad.

Scripts written in C# handles all operations behind the app. These operations are navigation, change of settings, saving data, managing Bluetooth, and similar. The scripts are written in Visual Studio Community 2017, and the project is structured in a solution file (.sln). A solution file is how Microsoft Visual Studio keeps tracks of information on the environment configuration and packages included in the project (Microsoft, 2019).

A Unity application is organized into scenes, a container for an environment that has common properties. Several scenes are usually used to separate different levels in a game, where each level differs much in visual contents and functionality. In the implementation of this app, it is only used one scene with several components that compose the functionality of the app. If the game mode had been implemented, it would be natural to add another scene for the game feature, and in the game feature; one scene for each virtual world. Figure 33 Unity Engine in 2D design mode, design window to the left and display window to the right. Figure 33 shows the Unity editor when the scene is selected, and the start page component within that scene is selected for editing.

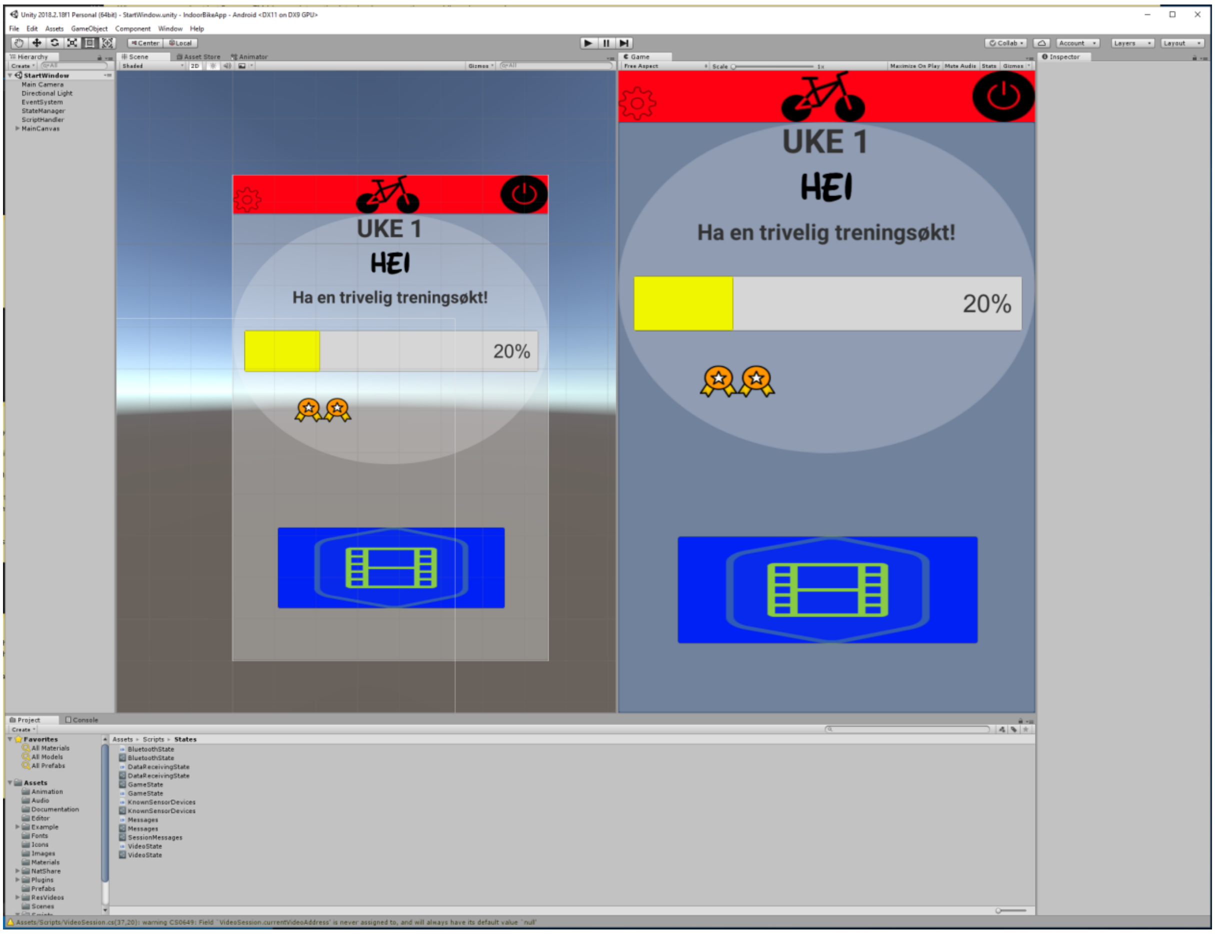

Figure 33 Unity Engine in 2D design mode, design window to the left and display window to the right.

App implementation

The core of the app is built up of handlers managing: functionality supported; states maintaining game data, and panels displaying the app content. A chart shown in Figure 34 illustrates how these parts interact with each other and how the data is shared between them. The illustration includes the vital functions of the app with some details left out to make it easy-to-follow. Handlers are classes that maintain a set of functionalities that the app needs to function. States are data objects that contain data that needs to be shared between handlers. Panels are the views that are displayed on the screen and that maintains the user interface.

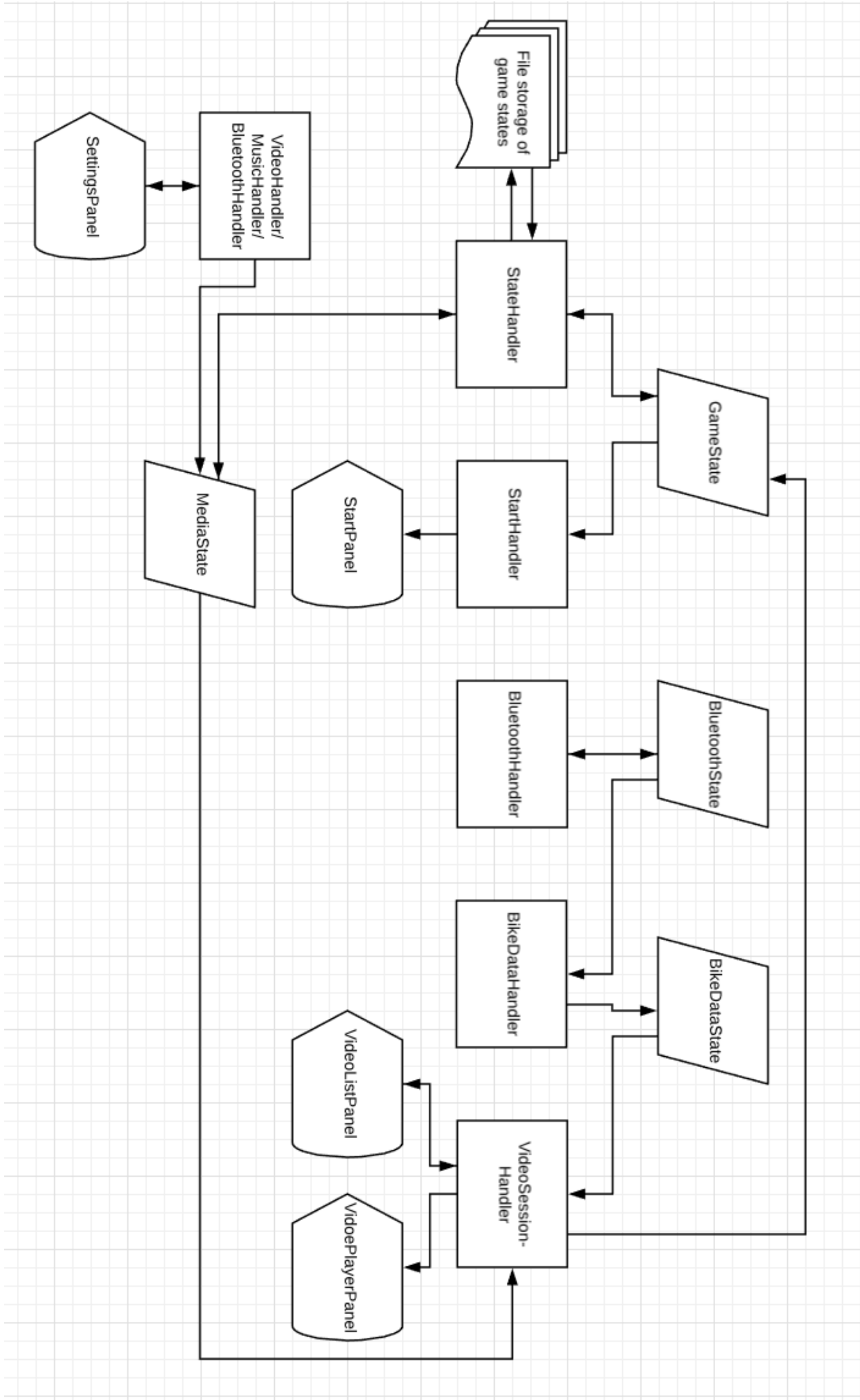

Figure 34 App implementation with handler classes, data management, and display panels. The arrows tell how data flows and where it is displayed.

To understand the application implementation, knowing the essentials of Unity scripts lifetime is useful. When the app starts, the scene is loaded, and initialization functions for each object in the scene are called. These functions are Awake and Start, and the objects in this implementation are all the handlers. Awake is called and completed before the Start functions are called. Each handler may use this function, but it is not required to do so.

The StateHandler loads the application data, such as user data, and application settings during the Awake execution and stores them in GameState object. The StartHandler fetches the user data loaded previously to display it in the on the status page, which is the first view of the app. The available videos will be listed in the VideoListPanel so they can be selected from.

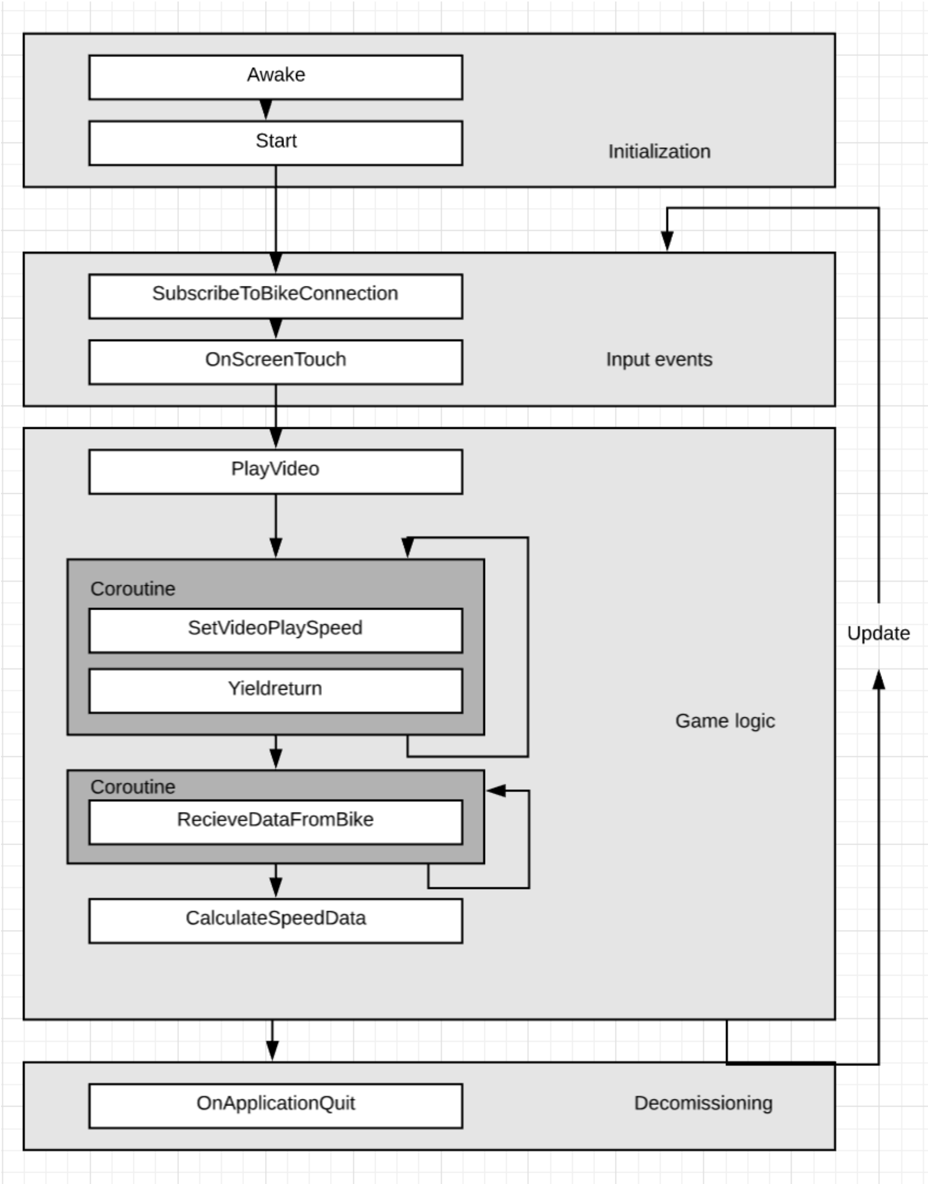

Figure 35 The execution order of the application.

When the initialization is done, the app starts running in cycles where each cycle performs tasks and a frame update. A task may be a function that handles user interaction or shifting the display view frame. When there is no function running, the Unity control renders the current frame again. Unity control is the app organization execution that a developer cannot interfere with, such as handling the cycle updates. Figure 35 shows a simple overview of these cycles and what may run within each cycle. A function that is called within a cycle runs to completion before returning. Coroutines allow a function to pause and return control (yield) to the Unity cycle and then resume in the next cycle (docs.unity3d.com). Each handler class has an update function that is called in each cycle that can be used to update states or frame content.

The BluetoothHandler runs managing of connection in the Update function depending on the current connection status. In the first cycle, a search for compatible Bluetooth devices is started asynchronous, and then a callback function notifies when a device is found. The status of the Bluetooth devices is checked in each cycle, and when a device is found, the function that connects to the device is started. When the connection is verified in a callback, the subscription to the device is initiated in the following cycle, and data is received in an asynchronous callback. The data is put in a shared data state where the BikeDataHandler can reach it. In each update cycle, the Bluetooth data is read and calculated into speed represented with the unit meter-per-seconds by the BikeDataHandler. The speed that is calculated is written to the shared BikeDataState.

When a user interacts and selects a video, a video session is started in a coroutine. The selected video is set to start playing, but the initial playback speed is set to null. The video session then yields out of its coroutine to let the calculation of playback speed happen. The calculation of playback speed is done with the speed data from the shared data container BikeDataState. When the control comes back to the video session coroutine, the playback speed of the video is updated before the control is yielded further again. The coroutine managing the playback speed is ended when the video is done playing, or the user quits the current session. The session data, such as activity time, is written to the user data in the shared GameState object where it is available for updating the status bar on the start page.

Connection to bike sensors

The connection technology Bluetooth Low Energy (BLE) was used to interact with the Tacx Smart Flow trainer and the Wahoo cadence sensor. This connection between the app and both sensors is achieved with Fitness Machine Service (FTMS) (Sports and Fitness Working Group, 2017). The FTMS is a standardization of the BLE communication for many fitness trackers and sensors on the market. Since both the Tacx Smart Flow trainer and the WaHoo Cadence sensor (Figure 36) uses FTMS, the connection can be initialized the same way for both sensors. The data from the two different sensors are used to get the current cycling speed of the user, although the way calculate is different between them. The WaHoo Cadence sensors provide cadence data during a training session, which then is estimated to cycling speed. The Tacx Smart Flow trainer provides data that allows calculation of the current speed on the power wheel, which then is used as the cycling speed in the app.

Figure 36 Bike sensors that support connection over Bluetooth Low Energy and measures either speed or cadence can be used in this system.

A software package called *Bluetooth LE for iOS, tvOS and Android (Shatalmic_llc, 2018)* was bought from the Unity Asset Store (Unity_Technologies, 2019) to simplify the implementation of the connection. This software package includes scripts compatible for Android and iOS uses the Bluetooth service on the devices. A script written in the Java programming language handles all necessary calls to Bluetooth service on Android, while a script is written in C++ programming language to manage calls at iOS. Then the software package provides a C# script that manages the interoperability between the two different programming languages. The script is used to scan for devices, connect to a suitable device, subscribe to data from the device, and disconnect the device.

The scan process finds devices that broadcast Bluetooth signals and checks if the device supports speed or cadence measuring. The broadcast from each device contains meta-data about it, such as name and services that it supports. The Bluetooth specification[16] tells that the identifier for cycling speed and cadence service is 0x1816, which is used to recognize these devices their addresses. The address is used to connect to the device, which allows subscribing to its service(s). The characteristic of cycling speed and cadence has to be used to specify what service should be subscribed to, as most devices often offer several services. The Bluetooth specification[16] tells the characteristics for services, and the one for cycling speed and cadence is 0x2a5b.

The data that is received with the subscription is represented in hexadecimal, which must be interpreted according to the FTMS specification (Sports and Fitness Working Group, 2017). Figure 37 shows an example of data that is received from the Tacx Smart Flow trainer. The data type tells what data is transmitted in the data records, and for the example Figure 37, it tells that this record contains

[16] https://www.bluetooth.com/specifications/

current wheel revolutions and the time for the last measurement of wheel revolutions. The calculation of current speed is then performed like this:

speed = (difference in two successive wheel revolution values * wheel circumference) /

(difference in two successive last wheel measurement time values)

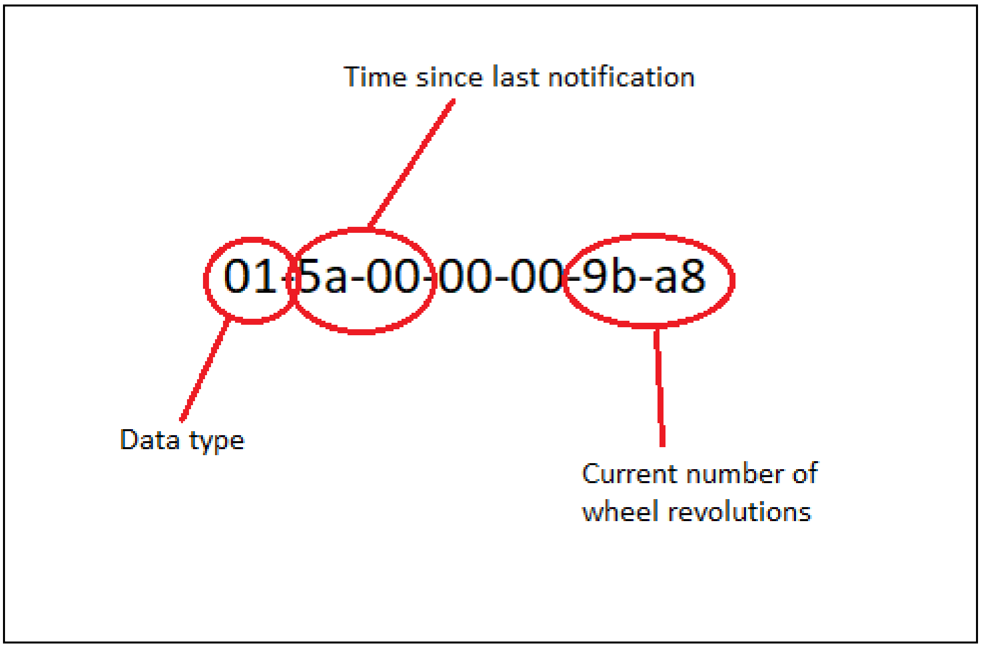

Figure 37 An example of data received from bike sensors.

The measurement data from the embedded computer and display on the ergometer bike was used to estimate speed from the cadence data. By looking at the measurements of cadence from the mounted sensors and comparing it the speed in the embedded system, the unknown factor was the solution to the equation:

cadence*unknow factor/ time = current speed

The unknown factor is the necessary element to calculate cycling speed from the measurements of cadence. The cadence data record has a similar set-up in hexadecimal values as the speed data, except it has the flag for cadence data type and gives a number of crank revolutions.

speed = (difference in two successive crank revolution values * factor) /

(difference in two successive last crank measurement time values)

6.3 Not implemented features

There are some features that are not implemented but have been designed or is stated in the requirement. The reason for not implementing these features are mainly due to a shortage of time to complete them.

The game mode design has not been implemented, which include all the requirements related to biking in a virtual world. However, it was considered how such an implementation could be. It is possible to buy assets from the Unity Asset Store that provide a baseline for virtual worlds, which would make it easier to do the design development. The steering could be done by fetching data from the tablets/iPad’s embedded accelerometer data, but it would only be an option for the three-wheel bike as it has a moveable handlebar. Other possible controllers for steering could be to use buttons mounted on the handlebar that gives signals when pushed to go right or left.

Another feature that was not implemented was the adjusting of resistance according to the up- and downhills in pathway videos. It was attempted to investigate the Bluetooth characteristics from the Tacx Smart Flow trainer, but the service for adjusting resistance was not labeled as the speed and cadence service. The author contacted the production company to get help for understanding how to adjust the resistance over Bluetooth, but they responded that they were not able to provide help at the moment because the developers were not in the office. They said the developers would be back in a couple of months, but the feature has not been taken any further as it was close to the delivery of the project.

The support for surprising animals and figures popping up in pathway videos is not fully completed in the prototype. There are animations added to videos, but it is done in a separate video editor. A more optimal solution would be to add this animation as an app functionality. This would make it possible to make the animation content more dynamic and therefore more surprising and exciting.

The last requirement that is not fully implemented is the support for English text and audio commands. The testing of the system was only planned to be performed on Norwegian speakers, and therefore the support for the English language has not been prioritized. However, to support English is considered relevant as the intention is to make the system available for everyone that can use it. That being said, it should be considered to support other languages as well, and the implementation for language support should make it convenient to add more languages to the system.

6.4 Summary

This chapter explains how some of the main aspects of the design have been implemented. Among these aspects are the development platform and its utilities to develop an exergame app, how the code behind the app is structured, and the essentials around receiving sensor data through Bluetooth Low Energy. There are some of the designed requirements that have not been implemented, mainly due to the time limitation for this project. The more essential features that are not implemented yet are the game mode and the adjusting of cycling resistance.

7 Test and Results

The testing of the system consists of several parts. One of the parts was the testing of functionality done through the development to establish that new features behave as expected. More thorough testing of the system was done by letting one of the experts[17] test the system and give qualified feedback. To achieve realistic testing, the system was placed on a daycare institution for individuals with ID. This institution is a municipality service that offers activities and events for individuals with ID.

7.1 Testing procedure

Testing with expert

The testing with the expert was set up in a room at the university (Figure 38). In the testing the three-wheel bike was used and the tablet. The testing was done in a 15-minute session.

Figure 38 From usability test with an expert using video mode.

[17] Henriette Michalsen - psychologist and PhD candidate.

Testing at the day-care institution

The test phase was set up to last four days, Monday to Thursday, where the system was at the day-care institution's disposal all the time. The system was set up in an activity room at the center where there already stood two other ergometer bikes and a treadmill. The staff would present the system for the users who had agreed to participate and oversee the execution of test sessions. If any of the users did show signs to dislike it, they could stop and do not have to do it anymore. Three users had agreed to test the system and had signed the written consent (see "Ethics" below for more info).

The system was tested using the three-wheel bike and the Tacx Smart Flow trainer. A simple user manual was sent alongside the system to show how to use it, which is shown in Appendix 3. The system was set up with the Samsung Galaxy Tab A 10.1 with the app installed. There was only the video-mode available since the game mode is not jet implemented. In the video mode, five different videos were available. Two of the videos were recorded bike trips through the city center of Tromsø, which was three and eight minutes long; two of them were Mr. Bean cartoons that were each eleven minutes long; and the last was from a bike trip video through Switzerland alps on 14 minutes, extracted from the Tacx videos with permission from the Tacx Inc company.

The test users were only with staff at the center during the tests, where one of them assigned to be our contact point. After the test phases, the employee that had been our contact was interviewed about how the testing had been from an objective view. The contact person was asked to give an opinion on the system based on the observations of the system in use. The contact person, which was a member of the staff, is used to be with individuals with ID and has experience with them.

The solution with the ergometer bike was not tested as it were some trouble with the connectivity to the sensor. The problem was fixed, but then it was too close to the test period to arrange a test phase for it as well at the institution.

Demo for the reference group

A demonstration for the reference group was done near the ending of the project to receive feedback on the prototype. The presentation was made with having the app running on smart-phone mirroring the screen to a large monitor which everyone could see. The solution with the ergometer bike was used to demonstrate the system, as the three-wheel bike was still at the day-care institution. However, a video that demonstrates the system with the three-wheel bike was shown in addition to the practical demonstration. At this meeting, the attendants contributed to a discussion of the system and answered a SUS scale to say what they thought of the usability for users with ID. In addition, they came with a proposal on new features that could improve the system.

7.2 Results

7.2.1 SUS – system usability scale

The results from the SUS scale is calculated by summing the points for each statement, where each statement gives a score from 0 to 4. For statements 1,3,5,7, and 9 the statement score is the scale point position minus 1. For statements 2,4,6,8, and 10, the statement score is the scale point position minus 5. Then the sum of all scores is multiplied by 2.5 to give the SUS-score for each form of statements. The graph in Figure 40 shows how the calculated score from each form that was answered. Bangor et al. (2008, 2009) have set a correlation between the SUS score and adjectives and a letter scale (Figure 39). They propose that this relation is relevant when determining how usable a system is (Bangor et al., 2008).

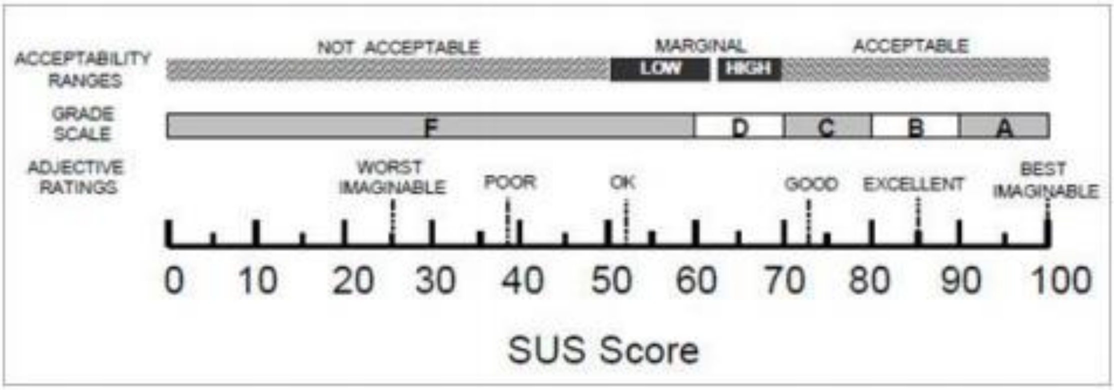

Figure 39 A grade ranking of SUS scores from «Determining What Individual SUS Scores Mean: Adding an Adjective Rating Scale» (Bangor et al., 2009).

The highest SUS score calculated from the SUS-scale responses was 90. With Bangor et al.'s proposal to evaluate SUS scores, a score of 90 gives an A grade and is considered highly acceptable according to the grade ranking in Figure 39. The lowest score calculated from the responses is 50, which in the acceptability ranges is on the limit of unacceptable and marginal usability. The average score of all responses is 70, which is the limit of being an acceptable result. The highest score came from the results at the day-care center, where the system was tested on actual people with ID. Therefore, this score can be said to weight a little more than the other results from the reference group meeting. However, the high score could be influenced by being gathered through an interview, where the interviewee might answer positively to be polite.

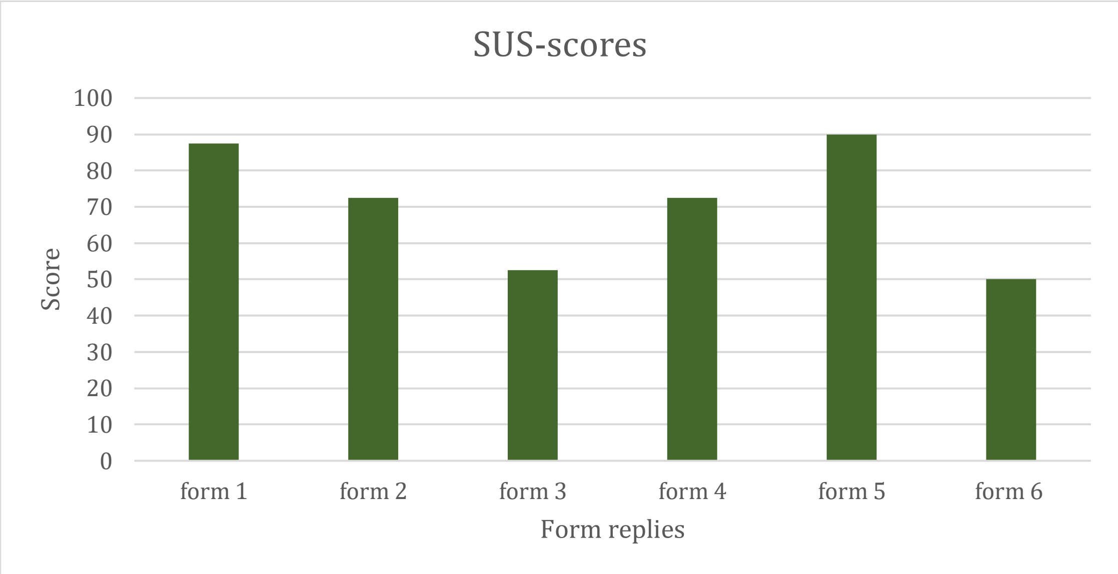

Figure 40 SUS-scores for each form received.

The diversity among the calculated scores are high, and a reason for this can be the diversity among individuals with ID. We know from the theoretical research that the severity degree of ID is divided into mild, moderate, severe, and profound, based on the abilities an individual has measured with IQ scores and other ability tests. It is likely that among the parents and institution staff, the experience is related to different degrees of ID, and therefore, the answers will vary relatively.

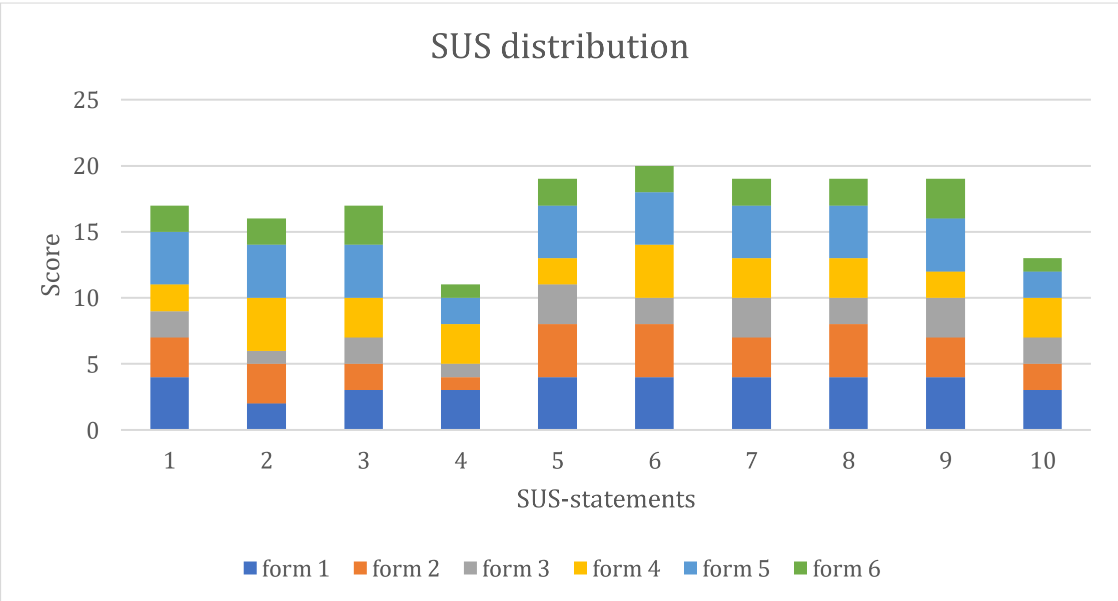

Figure 41 Graph showing how the scores disperse on the SUS-statements.

When looking at the scores of the different statements in the SUS-scale, there are two that separates from the others with having a significantly lower rating, statement four and ten. The statement is about if the user with ID would require support from personnel to use the system. This might be because of the settings being more advanced, such as setting speed limit or constructing music playlist, where it is likely that they would require help. Starting an exercise session without editing settings seems to be more legitimate as statements such as nine have a high score. Statement nine tells that a user is confident in using the system alone. The low score on statement ten is related to how much a user needs to learn to operate the system. It is reasonable to think that a user needs to be told how to use the system before engaging it and that the score is relatable to the score on statement four.

7.2.2 General feedback

The testing done by the expert was conducted before the testing at the institution. The feedback was that the system was fitting the requirements that had been discussed. The expert said the system seemed promising and that it was ready to be tested in a more realistic environment.

In the following text, the test users at the day-care institution are referenced to by user one, user two and user three. All three of the users were experienced users of tablets and iPads and often used YouTube to watch their favorite videos. The users were also experienced with playing games on smart-phones or tablets, and at the institution, they have scheduled periods for video-games or surfing the internet. In general, all users enjoyed the system; however, there were different experiences during the intervention. All users enjoyed watching the videos that were available in the app. However, when biking through the city center was done once, they did not have the same enthusiasm the second time. The entertainment videos, such as the cartoon, appeared to be more interesting. Two to the users watched the cartoon videos more than three times, while one watched them twice.

Users one was not familiar with how to use a bike and did not know how to operate the pedaling that would lead to the playing of a video. After being instructed by the staff member, user one eventually learned how to use the pedals to cycle. User two watched all the videos through exercise sessions two times and then said it was not interesting anymore. This user had a wish for more cartoon videos and videos that lasted longer, like 20-30 minutes. User three also used all the videos in sessions and said that it was interesting but was confused with that he could be biking through the city center at the institution’s activity room. The answers related to efficiency were: to start an exercise session went quickly, estimated 3-5 seconds; except the user that did not know how to cycle, there were no problems, and all users were able to start an exercise session by themselves.

The feedback from the reference group meeting was the system was promising as it is, but they also suggested interesting improvements. One of the proposals was to add a scoreboard based on distances achieved in training sessions where it is possible to compete against other users of the app. One of the members at the meeting working at an institution said that this was likely to make the users engage more, as their members enjoyed competing against each other. Another wish was the possibility to watch longer videos such as movies, where you could start to watch a movie in a session and continue in another exercise session. The feedback is valuable if the project is to be developed further.

7.3 Ethics

Before the participants at the day-care institution were doing the tests, written consent was gathered from all of them (Appendix 6). As the parents are authorized decision makers for the actual test users, they are the ones who signed the consent. The consent gave information about what participation involves; that it is completely voluntary; what happens to the information gathered; and who is responsible. For those of the actual participants that can read to some extent, we made a simpler consent that they could sign (Appendix 7). To ensure the anonymity of the participants in the test, information such as age, type of ID, gender, or other characteristics were not included in the results. The information about the results was obtained interviewing the employee that had been responsible for supervising the tests for the users. An option could be to use a questionnaire, but since it requires a thorough application process to get permissions to gather data, doing interviews were preferred this time.

The attendants at the reference meeting all agreed to answer the SUS-scale, and all answers were kept anonymous.

7.4 Summary

This chapter describes the testing the results from it. The testing described in this chapter has provided the most important evaluation foundation for the system prototype created in this project. The results have given a qualified indication for the system and how well it is working to solve the problem of this project.

8 Discussion and Future work

In this chapter, it will be a discussion of the system made, and how well the preliminary research questions are answered; then the importance of the project will be evaluated and how the project compares to previous studies and solutions. It will also be evaluated how features can be improved and what should be in the future work to develop the prototype to a more sustainable product.

8.1 Discussion of results

The results from the testing at the day-care institution were provided through an interview with one of the staff members. One person's opinions are a small basis to assess the system on and tell how well it succeeds in the project goals. However, the interviewee has long experience with individuals with ID by working with them for a long time and the results can be considered to have a significant relevance as test results. The presentation of the implemented prototype for the reference group has improved the foundation for assessing the system and gives better quality to the SUS-scores.

The SUS-score results imply that the system has achieved almost acceptable usability for individuals with ID. The significant differences between the scores calculated from each SUS-form is an indication that the app is highly acceptable to use for some individuals with ID, while the usability for others is of lower quality. This was also the observation that the staff member at the day-care institution reported. One of the test users understood right away how to use the system, while the two others need a little more assistance first. We did know from the research that the individuals with ID often receives assistance from institution staff or family members when performing different activities. Taking this fact into the assessment of the usability justifies saying that the system is user-friendly for individuals with ID, despite receiving low SUS-scores in some of the forms.

We learned from talking to parents that their child with moderate ID has learned to find their favorite song on YouTube, which is a mediocre advanced app. Therefore, it could be considered to make a more advanced system and include more features in the app. However, as stated in the theory chapter, some of the barriers for individuals with ID to not engage in physical activity were that they lacked motivation for it and often thought it was boring. Because of these types of barriers, the motivation for individuals to learn how to use this app is presumably low, as it requires the user to do physical activity. The design choices that give reasons for not using the system, such as including more advanced features, has therefore been avoided to the extent that it is possible.

Using amusing and entertaining videos as a reward has proven to be promising for encouraging physical activity on a stationary bike among the test users. All the test users enjoyed watching cartoon videos while cycling, and two of them also found the rides to the city center entertaining to watch. Making more videos available is then likely to improve the effect of the system, which has always been a point with the design. The entertainment content available in the system should be dynamic and customizable to adapt the individual preferences among the user group.

One of the users that tested the system did not understand how the display could show videos of the city center when cycling in the activity room of the institution. However, the user enjoyed using the system watching the cartoon videos while cycling and had no problems with them. The playing of videos immediately has given a clear correlation between the exercise that is performed, and the reward that is received. There was a user during the testing that did not understand that to watch the video; it had to be registered cycling activity. However, the user did eventually discover how it worked by receiving some initial instructions from the staff member. These results show the advantages of keeping the rewards from being too abstract as recommended by the experts.

One of the test users were able to start a session by themselves the first time and the two others managed it the second time they used the system. Starting a session includes activating the tablet, starting the app, and navigate to the video list and select a video, and then be ready to start cycling. These test results indicate that the design has a user-friendly UI for individuals with ID which has been an important goal for this project. Using the FTU app as an inspiration for the UI design choices has proven to be wise, as well as using relevant literature such as the W3C (Seeman and Cooper, 2019). The promising results from the testing indicate that adapting aspects such as usage of symbols, short-text, and audio commands is a justified decision.

Other important aspects with the design to make it user-friendly has been to make the connection over Bluetooth set up automatic. The app searches for available devices that support measuring the right type of bike data and connects to it. Avoiding that the user must navigate the UI to find the correct device in a list, simplifies the usage of the system. The decision to not have a log-in prompt when entering the app is also based on making it simpler to start a training session. The possibility to adjust the speed limit for videos to start playing makes the system more adjustable to the differences in shape among the users. Also, implementing the resistance adjustment on cycling would be beneficial to make the system more adaptable for individual differences among the users.

8.2 Answer to research questions

This section will go through how this project has managed to answer the preliminary research questions in the introduction.

Main research question: How to improve physical activity for people with intellectual disability with exergaming and indoor bike cycling?

Understanding the users' needs have been essential for developing a prototype that will function well as an exergame for individuals with ID. This understanding has been achieved through seminars, workshops, and meetings; where experts, parents, and institution staff members have been present. This project has created a prototype that combines measuring of bike activity data and an app that receives the data in an entertainment system. Results from usability testing of the system indicate that the system has made physical activity on a stationary bike more amusing for individuals with ID. The above question is set as the main research question for the project. To emphasize the different parts of the problem, it was divided into sub-questions. How these questions have been addressed will be summarized below each of them.

Question 1: What type of exergame elements would encourage individuals with intellectual disability to use a stationary bike?

By doing research on behavioral change, individuals with ID, and possibilities in technology, the answers were found to question 1. We learned that many of the individuals with ID enjoy watching videos such as cartoons and TV-shows and that they often use tablets or iPads. From the theory around behavioral change for individuals with ID, it was clear that the rewards that this system should give had to be immediately as the physical activity was conducted. The interest and preferences among individuals with ID differ immensely from individual to individual. Therefore, the content that is provided in the app should be dynamical to suit the different users.

When discussing with the parents, they suggested making a game that could be controlled by the bike. This game should contain an educational aspect, such as spelling words or picking up garbage. We know that many of the individuals enjoy playing games on tablets/iPads and smart-phones, which gives the motivation to create this feature. There was designed a proposal for how this game could be made, but it was not implemented due to the shortage of time.

Question 2: What makes an exergame system suitable to use for a user with intellectual disability?

Learning the challenges that are common for individuals with ID has been essential for customizing a design for this group. The FTU app and the W3C documentation has been important to reveal elements that make an app suitable for individuals with ID. Also, receiving continuous feedback on the design from experts and parents have led to altering of the requirements to achieve a better design for this group. The feedback on the prototype gives an indication that the system has a user-friendly design for individuals with ID, but it is recommended that they have available support from someone capable. With a part of the assumptions being that the vast diversity in the type of disabilities among individuals with ID, and some of should be able to use the system by themselves, while others might need support to different extents to use it.

Question 3: What type of exercise equipment can be used with an entertainment system for individuals with intellectual disabilities?

We learned that many of the individuals with ID enjoy riding bikes outside when the weather is nice at summer time. However, nice weather and summer are not common in places like Northern-Norway, and the number of bike rides through a year is limited. Therefore, to take advantage of that many individuals with ID enjoys bike cycling, this system uses a stationary indoor bike mounted with capable sensors. We wanted to be able to use a regular bike in the system since the relation to the outside biking is made clearer. However, when visiting the day-care institution, we learned that several of the users liked to use the ergometer bikes in the activity room, which justifies having this as an option as well.

8.3 Importance of project and related work

The introduction presents several sources states the prominent problem with ID and a sedentary lifestyle. The result from the systematic literature review gave several studies that were positive towards interventions with ID and exergames but emphasized that further studies should be conducted to gain better knowledge on the subject. There are recent studies that imply a need for more technological interventions with individuals with ID to improve their health conditions (Vázquez et al., 2018; Willis et al., 2018). The search for available exercise-apps for individuals with ID on the two biggest app platforms, Google Play and the iOS App Store, did not give an impression of a well-covered marked demand. The systematic search that was done preliminary in this project gives an indication that there is a low coverage on research on intervention with ID and exergames. There were few studies that specifically investigated how to promote physical activity to individuals with ID with use of technology. Such reports should give indices for doing an intervention of bike-exergame and ID in this project.

Chang et al. (2014) used an ergometer bike along with an entertainment system to encourage individuals with ID to cycle. In their solution, the activity was registered with an air mouse, which is a multimedia controller that can be used to operate a computer, smart-TV, tablet, and other devices[18]. The air mouse was mounted on the craft of the ergometer bike and sent signals to a minicomputer when it was in movement. The minicomputer plays a video on a monitor whenever there is some movement in the air mouse. If the movement registration stopped, the video would stop playing. This way of measuring the activity does not give information about the intensity of the cycling, as the air-mouse only registers movement or no movement. With sensors measuring cadence or speed, as in this project's system, there is provided a better impression on the amount of exercise performed, and it is possible to adjust the effort needed to yield a reward. Also, their system required an external mini-computer and an external monitor to control the entertainment system in comparison to using a tablet or iPad, which many of the users possess already. In the entertainment system, they provided a single video for each user. That makes it a more limited solution compared to the system in this project, which provides a list of videos that can be edited to suit the user.

In a state-of-the-art search conducted in chapter 2, there were found several solutions related to bike-exergaming for people in general. These solutions consisted of both a stationary bike with an embedded game controller and apps for tablets and iPads that could be connected to bike sensors, such as in this project's solution. Apps such as the Tacx Cycling App and the BitGym-app has a similar solution as they display videos of roads, streets, or paths when cycling. There are several reasons for not considering these solutions sufficient for the goal of this project.

[18] https://support.logitech.com/en_us/product/mx-air-rechargeable-cordless-air-mouse

The Tacx Cycling App is more aimed against experienced cyclists that like to do off-season training by virtually riding popular bike tracks around the world. Cycling these bike routes might be interesting for some individuals with ID, but it is likely that it is unnecessarily advanced for most of them. This app does not support usage with only a cadence sensor but will function well with the Tacx Smart Flow trainer. The BitGym has similar video content as the Tacx Cycling app but uses front-camera to register biking activity. The BitGym app cannot register the intensity of the exercise session. As it is stated before, measuring speed, distance, and time are preferred when solving the problem of this assignment. For instance, one of the wishes from the reference group meeting was to implement scoreboards for the users, and then it would be convenient to use distance to calculate a score.

Both Expresso Go Upright and the Playpulse system provides similar exergames where a unit is controlled in a virtual world. We learned that several individuals with ID are used to play games on smart-phones and tablets, therefore using these bikes might be feasible to use for them. The designs are not aimed against users with ID, but individuals that have a mild degree of ID might be able to enjoy these games. The Playpulse system is only available for companies where several bikes can be installed, and the Expresso Go Upright, is according to the company home page, not available in Norway. Shipment can possibly be arranged; however, the system is quite expensive as it costs 87 168NOK (~9912 USD)[19]. The customer service for the Expresso Go Upright might be quite inaccessible as they do not have any offices in Norway, which is unfortunate if there appear any problems with the system.

Costs related to performing physical activity is said to be one of the barriers for individuals with ID for participating in such events (van Schijndel-Speet et al., 2014b). The cheapest solution for this project system includes the Wahoo cadence sensor, a tablet, and the ergometer bike, which together costs 4623NOK (~ 526USD). If a household already possesses a tablet or iPad, and an ergometer bike, the cost is reduced to 399NOK(~45USD). Compared to the Expresso Go Upright, the costs for this project's system appears as a cheap investment. With the Expresso Go Upright, the user gets a system providing more features that justifies the price gap, but when considering usage for individuals with ID, many of the functionalities are likely to be too advanced. Also, with a lower price on the system, the investment risk is lowered, for instance, if it turns out that the system does not work as intended. This will make it more likely that more users test the system and therefore ends up using it.

In addition to the differences mentioned above, there are several aspects preferable in this project's solution. With the system in this project, we provide a dynamic selection of entertainment videos such as cartoon videos and TV-shows. We also allow the user to use the same bike that the users enjoy using outside, a relation that may make the activity more appealing. Developing an own system in this project gives more flexibility to customize the system against users with ID. We have been free to add features that have appeared through the user involvement with the reference group.

[19] https://www.gymmarine.com/product/expresso-go-upright-bike/

An option to making the solution from scratch could be to try to integrate with an embedded solution such as the Expresso GO Upright or similar. If the production company were to allow such an integration, it likely that there would be several constraints to the development possibilities. Such a solution would limit the option in equipment that can be used and is also likely to become more expensive than the solution that is implemented. Also, in this project's solution provide more liberty to make features the way we find useful, and we are free to use the sensor data the way that seems fit for the purpose of the project.

8.4 Limitations and future work

8.4.1 Testing

There are some limitations related to the testing of the system that is conducted. The results of the tests from the day-care institution were received through an interview with one of the staff members. Having an objective assessment means that the quality of the results relies on the interpretation of the interviewee and adds the risks for the influence of bias opinions. With using an interview to collect the results, an interviewee might feel obliged to answer kind and polite and cause the results to be more positive than with using an anonymous questionnaire. The interview answers are written notes, which also can obscure the results, and increase risks for a biased influence when the notes are interpreted.

Other limitations with the testing are the extent and comprehensiveness they have been conducted. The tests that were performed at the day-care center was done over four days and included three test persons with ID. The positive result can be influenced by the excitement for new interesting equipment, but when the system is explored excitement may wear off. Having a longer test period would reveal, with more certainty the usefulness of the product. Having more test users would also increase the probability to reveal more lackluster and failures with the system.

The SUS-scale responses that were gathered from the reference group meeting were based on a presentation of the system from the author. The results are determent on the quality of the presentation and have less credibility than if the attendants had a chance to try the system themselves for a longer period. Also, the statements in the SUS scale had to be altered into objective opinions about the usage for individuals with ID and translated into Norwegian. This altering of the statements distinguishes them from the original model and the relevant research conducted around it.

Despite all the limitations for the testing that is conducted, the results still have the credibility to the extent that they should be included in the assessment of the system. All the opinions are gathered from people with broad experience with individuals with ID, as they have interacted with individuals with ID for long periods of time (years). Nielsen (1993, 2000) uses the findings in the study "A mathematical model of the finding of usability problems," to claim that five users will be enough to find 85% of the usability problems (Nielsen, 2000; Nielsen and Landauer, 1993). He also says that 15% of problems that is left is likely to be found by doing another test with five new users. The SUS-scores gathered in evaluation came from six forms, which means that they should represent a significant portion of the problems with the system. The translation of the SUS-statements was done carefully and in dialogue with professors within the computer science field. We believe that much of the relevance for each statement on the usability is maintain sufficiently to use them in the evaluation.

8.4.2 System features

This section will go through some features that could benefit from further development and implementation that would improve the system.

Media content

The videos used during a video training session are currently stored locally on the device that is running the app. An advantage with this way of doing it is that it does not require an internet connection for the app to function, which makes the system more flexible when choosing a position for it. Also, if parents have a video from a vacation or similar that they would like to add, they can transfer it to the tablet and include it in the app. However, there are troubles when having the app on an iPad, as iOS handles app access to local storage a different way than Android. A solution that works for both platforms is not jet devised because of shortage in time.

There was tried to have the videos in a Dropbox folder such that the app could get them from there instead of the locale files system. The app was able to stream the videos from the online Dropbox folder, which solved the problem with accessing locale files on iPads. However, when the video was supposed to play faster proportionally to the cycling phase, the streaming rate of the video became too slow, and the frame froze. As the testing was done at the university network, which has a solid bandwidth for internet connection, it is likely that the streaming from a Dropbox folder was not functioning properly at either client side, or from the Dropbox server.

There are other reasons that this solution is not optimal in addition to not function properly on iOS devices. To add a new video to the system, it must be available as a file and then transmitted to the local storage of the tablet or added to the Dropbox folder. The problem with this solution is that it is not common to legally have access to video files from TV-shows or movies. Today such content is commonly accessed through streaming providers such as Netflix, Amazon, or YouTube, where you get access to the video content, but do not receive the actual video file. A further investigation should be done on how to include streaming providers’ videos into the app, which would improve the video possibilities for the system. If there are streaming providers that have an open API, it should be integrated such that the content is available, but where only a chosen selection is shown in the app. If the provider integrated requires payment for the content, it is likely that this must be done through the providers' system. Most users with ID are likely to need help with this setup and selecting a set of videos that are preferred, but the setup must be manageable for parents and institution staff.

In the development process it was conducted a brief investigation on how YouTube could be integrated as a video provider in the system. In the Unity Asset store, a developer has made an integration solution for streaming YouTube-videos[20]. This would give access to a great number of videos, which makes it likely that all different preferences in video content can be met by the system. If it is possible to fetch a playlist from a user on YouTube, parents or staff at institutions could composite this list through the YouTube website or app. In addition, the benefits of using YouTube is that many of the parents and institution staff are likely to be familiar with using YouTube; and there is documentation that explains well how to use YouTube.

A possible problem with using YouTube is the temptation to switch to the YouTube app and watch the video without having to cycle on the bike. A prerequisite for this solution may be that a user must want to use the bike intentionally, and then the YouTube-videos will make it more interesting and amusing. It is common today that tablets or iPads offer to lock of apps to restrict usage for children. With locking the original YouTube app, or other similar apps, the temptation for shifting apps can be avoided.

The music is made available as local files on the device as well. However, it is easier to find available music files than video files. For instance, Amazon allows buying of music mp3-files and have many songs available for free[21]. Since it is possible to add all music available on the tablet in the app, it allows the user to choose the music of preference. A drawback with this solution is still the problem with accessing local files on an iOS iPad. Preferably, a solution that works on both iOS iPads and Android tablets should be implemented. Most of the music available today is published on YouTube and can be listened to from there. With the integration of YouTube, the issues with local music files might also be solved. Using local music files should still be an option to provide flexibility for users.

Server

The prototype made in this project functions without a server backend and do not require internet access. However, there are reasons for having a server for this system. It would be useful to have an administration webpage where parents or institution staff has a user with control for a selection of relevant users of the system. The administration webpage can be used to set the configurations for each user, such as change the videos available, set music playlist, setting activity goals, or other relevant settings. If the YouTube solution is integrated into the system, videos might be added in the administration webpage by finding links to them and put them together in a list. The list of videos would then be synchronized to the app such that the videos are available for the user. The users' activity data could be displayed in an intuitive way for parents or staff if they would like to evaluate the activity levels to the user.

Having the user data in a database managed by the server makes it possible to change devices by synchronizing the data to the new device. A user will then be less dependent on a certain device to maintain the user data and could quickly shift to another device if necessary. The server could also be

[20] https://assetstore.unity.com/packages/tools/video/youtube-video-player-youtube-api-v3-29704
[21] https://www.amazon.com/MP3-Music-Download/b?ie=UTF8&node=163856011

used to keep track of scoreboard for a selection of users that have been set-up. The scoreboard should be displayed on a webpage that can be shown to the users at an institution. Institution staff should be able to composite a list of contesters for the scoreboards at the administration webpage.

If the game mode is implemented, the server could be used to provide an update of contents to the games. This could be providing new things to gather, new virtual worlds, or other aspects in the games.

User management

Many of the new features mentioned under the server section rely on a user to have a private account in the system. In the prototype, a user can get a user name under the settings and then the activity registered from then will be related to that user name. To shift between users, the name must be changed under settings and put the name of the user to shift to. This is relying on that the user names must be remembered four changing back to a previously used account. The management of users has not been given more focus in the app since it was expected that there was only one user per device. When the scoreboard is implemented, it should be prompted more that the user should have a name and photo that is familiar to the user. This would make it easier for the user to recognize themselves on a scoreboard and to understand who the other competitors are.

A staff member at an institution told that their members with ID often borrowed a device from the staff and that several users used that device. In this case, the app should have better user management where an overview of all user on a device is displayed and add a password that is required to gain access to user data. Having a password would also be recommended when the user data is stored in a database and it is possible to log into the account on several devices. It should also be a way to ensure that a password can be reset in a secure way if the original password is forgotten. This could be managed in the admin webpage where a responsible, such as a parent or staff worker, has an account that allows access to such actions.

Security and privacy

When the user data is stored locally, the assumption was that a user would use its own device and therefore ensure that no one else could get access to the data. Also, the user is not prompted to write a password when entering the application to make the system easier to use. However, the user data should be protected with a password requirement if the user data is stored externally, or the device is shared between several users. Implementation of password usage is important to ensure that users do not have access to each other’s data. When storing user data to an external database, it is important that this process is done in accordance with the General Data Protection Regulation (GDPR) (European_Commission, 2018). The GDPR has several regulations that have to be considered when handling user data, such as informing the purpose of storing the data and getting consent from the user to store the data.

8.4.3 Future work

There have been given suggestions on how to improve several features of the system above. This section will make a summary of the features that are discussed to be improved, features from the last reference group meeting, and the requirements that are not implemented.

- Adding the option for YouTube videos to extend video content.
- Add the possibility to play music from YouTube.
- Support longer movies with continue later functionality.
- Have a scoreboard overview that includes other users.
- Have a server for user management, updates of app content externally, and scoreboard webpage.
- Implement missing requirements described in the implementation chapter:
    - Implement the game-mode and add steering functionality.
    - Make fun animals and figures jump in on pathway videos.
    - Implement adjustable/dynamic resistance for Tacx Smart Flow trainer.
    - Extend language support to English and make it easier to extend to other languages.

Implementing these features will extend the possibilities and improve the probability for the system to be a success on a long-term perspective. Integrating YouTube and adding a scoreboard will be important aspects for maintaining the interest in the product over time. Adding game mode with dynamic content provided through a server will provide features that meet more interests and increase the potential for users of the system.

It is worthwhile mentioning that when implementing the new features, it is necessary to keep in mind that the usability for users with ID needs to be maintained. As we see, the SUS-scores gives indications on the usability prototype is assessed to be demanding for some users with ID. To achieve acceptable usability, it is recommended to continue with a close user integration in the development process, such as running usability tests and having reference group meetings. A possibility is to make the layout more configurable as in the FTU-app where it can choose how advanced the information is presented to the user. There could be added more voice commands for actions and activity statuses, but to mute them should be easy as they may appear annoying over time. For instance, in the beginning, the voice commands help the user to understand the system, but after the user is familiar, they are no longer required.

9 Conclusion

With this project, we have shown how close user interaction is valuable for developing an exergame for individuals with intellectual disabilities. We devised the project requirements through thorough research using relevant studies and reports; experts with knowledge and experience; and user engagement through parents and institution staff. Successfully implementing almost all the requirements for a functional product has resulted in a promising solution when assessing how user-friendly it is for individuals with intellectual disabilities.

We have shown that setting up a stationary bike connected to an entertainment system is effective to encourage physical activity. The prominent success factor has been to use entertainment videos as an immediate reward to motivate the user to perform cycling activity. The app that includes this motivation system allows the user to keep track of the activity conducted and to be motivated to complete a weekly goal of activity time. Another important factor has been to make the app configurable in content to adapt to the many differences that appear in the group of individuals with intellectual disabilities. The most prominent upgrade after getting the test results is to allow support staff to add videos dynamically, which is a part of the ideal design of the system.

Promoting physical activity among individuals with ID is often a battle that is done by parents or institution staff. They struggle to get their child or institution member interested in doing physical activity as they would rather take part in sedentary activities such as watching videos or surfing the internet. Making systems like this gives them a potentially helpful tool in this battle against a sedentary lifestyle amongst individuals with intellectual disability. As research has shown, individuals with ID is not the only group struggling with a sedentary lifestyle; and this system may also function well for other groups that are unmotivated to be physically active.

If the system does make individuals with intellectual disability engage in more physical activity, it can also be a contribution to decrease the risk for diseases and health-related problems that often follow a sedentary lifestyle. Municipality services could adopt this system as part of a larger activity program to promote a healthy lifestyle for individuals with intellectual disabilities. This project also shows a procedure for developing technical solutions for individuals with intellectual disabilities, with good indications that it will yield a successful solution. The project provides valuable information for research involving intervention studies on individuals with intellectual disability and technical solutions to encourage physical activity.

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Appendices

Appendix 1

Table: Table with database search from systematic literature review on interventions with ID and exergaming

Source	Search term	Found	Hits
Scopus	(TITLE-ABS-KEY (("intellectual disability" OR "mental retardation" OR "developmental disabilities" OR "mental handicap" OR autism OR "Down syndrome")) AND TITLE-ABS-KEY ((gamification OR "active video game" OR exergame OR "video game" OR "serious game" OR "Exercise bike") AND (exercise OR "physical activity" OR fitness)))	23	15
IEEE	(("intellectual disability" OR "cognitive disabilities" OR "mental retardation" OR "developmental disabilities" OR "mental handicap" OR autism OR "Down syndrome") AND ("physical activity" OR fitness OR exercise))	28	4
PsycINFO	(("intellectual disability" or "cognitive disabilities" or "mental retardation" or "developmental disabilities" or "mental handicap" or autism or "Down syndrome") and ("exergame" or "video game" or "video-game" or "serious game" or "exercise bike") and ("physical activity" or fitness or exercise))	9	4
PubMed	("intellectual disability" OR "cognitive disabilities" OR "mental retardation" OR "developmental disabilities" OR "mental handicap" OR autism OR "Down syndrome") AND ("exergame" OR "video game" OR "video-game" OR "serious game" OR "exercise bike") AND ("physical activity" OR fitness OR exercise)	6	4
Web of Science	("intellectual disability" OR "cognitive disabilities" OR "mental retardation" OR "developmental disabilities" OR "mental handicap" OR autism OR "Down syndrome") AND ("exergame" OR "video game" OR "video-game" OR "serious game" OR "exercise bike") AND ("physical activity" OR fitness OR exercise)	22	10
ACM Digital Library	(+("Down syndrome" autism "intellectual disability") +(exercise "physical activity" fitness "exercise bike"))	23	8

Science Direct	("intellectual disability" OR "cognitive disabilities" OR "mental retardation" OR "developmental disabilities" OR "mental handicap" OR "learning disabilities" OR autism OR "Down syndrome"), Title, abstract, keywords:(gamification OR "active video game" OR exergame OR "video game" OR "serious game" OR "Exercise bike") AND (exercise OR "physical activity" OR fitness)	18	14
Taylor and Francis	("intellectual disability" OR "cognitive disabilities" OR "mental retardation" OR "developmental disabilities" OR "mental handicap" OR autism OR "Down syndrome") AND ("exergame" OR "video game" OR "video-game" OR "serious game" OR "exercise bike") AND ("physical activity" OR fitness OR exercise)	206	2
Sum		335	
After removal of dublicates		210	

Appendix 2

Table: Summary of presentations at seminar "Physical activity with E-health support with individuals with intellectual disability"

Title	Presenter	Relevant summary
Physical activity with e-health support in individuals with intellectual disabilities.	Henriette Michalsen, Psychologist, Ph.D. student	Presented results from focus group interviews. Some critical factors for being physically active: support from parents and care-takers, be able to show someone what is achieved, predictability, coping ability of activity, amusing and fun, medals and rewards. Also said that it is necessary with a clear correlation between reward and activity.
Intervention studies to promote physical activity in individuals with intellectual disabilities.	Audny Anke, MD, Ph.D., Professor	Presents the challenge that the effect of m-health often wears off after six months. Few intervention studies with ID and E-health and struggles with dropouts and missing data in studies. However, the presenter is favorable to that mobile health apps interventions can provide a significant effect on improving physical activity levels.
Motivation for user engagement in e-health.	Gerit Pfuhl, Psychologist, Ass. Professor	Talks about motivation and volition and how e-health should support wishes to live a healthier life with feedback on achieved of predefined goals, make goals of wishes and support concrete plans. Emphasizes that engagement is for many a novelty effect.
Motivation og belønning. Hva vet vi?	Silje Wangberg, psychology, professor	Talks about inner (joyful, meaningful, coping, etc.) and external motivation (praise, money, candy, threats, etc.) and how inner motivation often should be preferred over external motivation to get a long-term effect. Predicted as most effective among individuals with ID is amusing/fun and immediately receiving candy or cake. To achieves a behavioral change takes a structured plan and much effort.
Friluftsliv tilrettelagt for utviklingshemmede. Aktiv fritid.	Eirik Dahl, project manager, and Sven Erik Tønnesen, general manager Smart Cognition	Shares their experience with creating an app for planning outdoor activities for individuals with ID. Emphasizes the importance of predictability and how the app should be able to express what is about to happen for an individual with ID or at least be helpful to do so. Use figures and

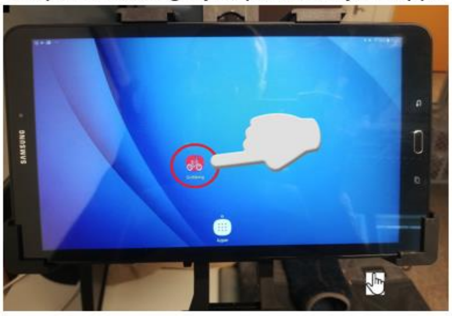
		icons to explain different activities and support audio.

Appendix 3

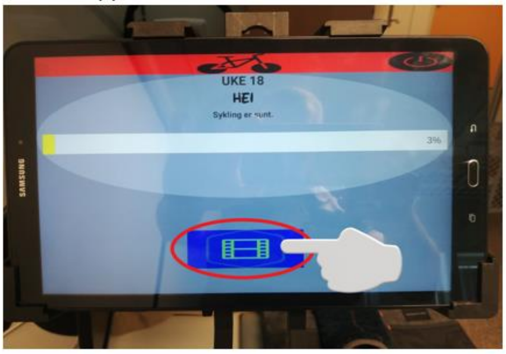
Basic user manual for MoviCycle system

Brukermanual MoviCycle

1: Åpne tablet og trykk på MoviCycle app:

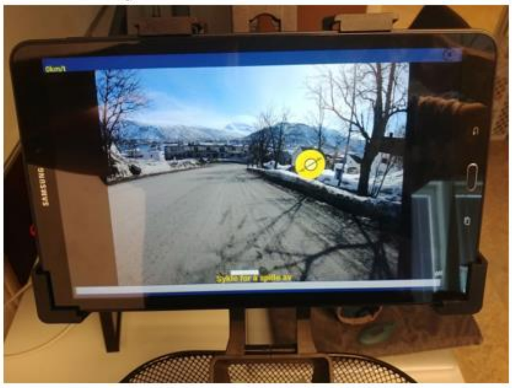


2: Vent til du ser denne siden, og trykk på videoknappen:



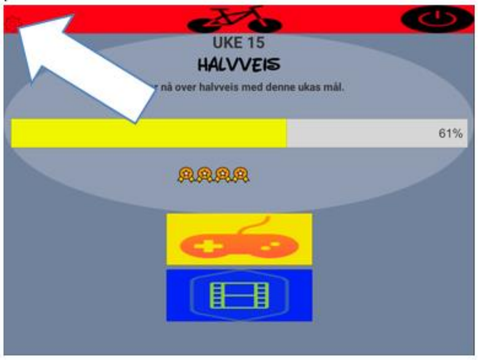
3: Velg en video i listen:

4: Start å sykle:



Brukermanual for innstillinger av MoviCycle

Gå til innstillinger ved å trykke på tannhjulet oppe til venstre på startsiden.

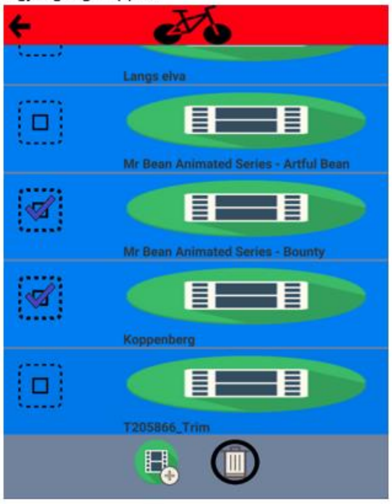


Endre bruker
For å endre bruker, rediger i det øverste feltet på instillingersiden og skriv inn et brukernavn for den nye brukeren. For å bytte tilbake til en tidligere bruker, må man skrive inn brukernavnet som den brukeren hadde.

Endre treningsmål
For å endre målsetning for treningstid hver uke, skriv inn ønsket antall minutter i feltet ved «Ukentlig mål min: ».

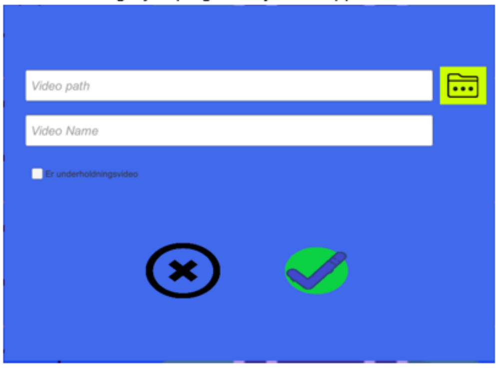
Endre avspillingsfart for underholdningsvideoer
For å endre farten som trenges for å spille av en underholdningsvideo, skriv inn ønsket fartsgrense i km/t ved feltet «Fart for å spille av video: ».

Endre på videoer tilgjengelig
Trykk på knappen «Endre på videoer» for å åpne et vindu som lar deg redigere hvilke videoer som skal være tilgjengelig i appen.



For å slette videoer ifra appen, velg en eller flere videoer med å trykke på de og trykk på «søppelbøtteknappen».

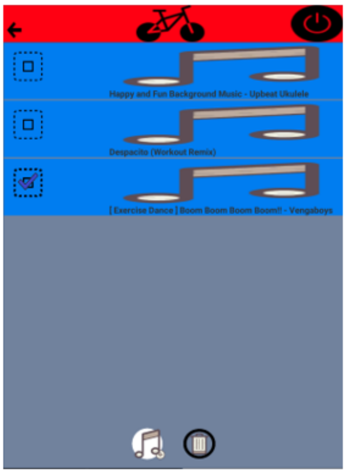
For å legge inn flere videoer, trykk på grønn knapp med videofilm og et pluss-tegn. Finn en video på enheten ved å trykke på mappe figuren og let frem videofilen i filutforskeren som dukker opp. Gi så videoen et passende navn og velg om det er en underholdningsvideo eller en «sti-video»* og trykk på grønn sjekk-knapp.



*Sti-videoer vil spilles av i en hastighet som følger målt hastighet på syklingen. Det vil også spilles musikk under treningsøkten.

Endre på musikk i spillelisten

Trykk på «Endre på treningsmusikk» på innstillingssiden for åpne redigering av spillelisten. Trykk og huk av en sang for legge den til i spillelisten. For å fjerne tilgjengelige sanger fra valglisten kan de velges for så å trykke på søppelbøtten. For å legge til flere sanger, trykk på noteknappen med pluss-tegn. Let så opp sangfiler på enheten med å åpne filutforskeren på samme måte som i redigering av videolisten.



Appendix 4

A submitted paper about the project: «eHealth Approach for Motivating Physical Activities of People with Intellectual Disabilities»

A paper was written about this project and two other projects within the same scope and submitted to the workshop Digital Transformation for an Inclusive Society – DTIS. The workshop is a part of the conference the 18th IFIP Conference on e-business, e-Services and e-Society (https://www.i3e2019.com/dtis). The paper has now been accepted.

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eHealth Approach for Motivating Physical Activities of People with Intellectual Disabilities

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Abstract. Compared with the general population, persons with intellectual disabilities have worse health, lower levels of activity, and greater barriers to participating in fitness activities. As low physical activity is a determinant of health, and as increasing activity has positive effects on cardiovascular and psychosocial health, identifying effective interventions for use in everyday settings is exceedingly important. In this position paper we present the design and development of prototypes of game-based eHealth solutions for behaviour change and health promotion by influencing physical activity. Participatory design and agile development have been applied in this project to deliver a system based on three solutions to promote, motivate and maintain physical activity in people with intellectual disabilities: Guided in-door bicycle exercise, guided out-door exercise and guided mild workouts. All the solutions provide virtual environments and motivation features adapted to people with intellectual disabilities for better engagement.

Keywords: Intellectual Disability, eHealth, mHealth, Physical Activity, Gamification.

1 Introduction

1.1 A Subsection Sample

Intellectual disabilities (IDs) are intellectual and functional impairments caused by a neurodevelopment disorder [1]. The prevalence of IDs ranges from 2 to more than 30 per 1,000 children [2], and the classification of IDs depends on the severity of the deficits in the adaptive behaviour (measured by the Intelligence Quotient –IQ). People with IDs are on an increased risk of health-related problems and their health needs are often unrecognized or unmet.

Among the comorbidities of people with IDs, metabolic related diseases are the most prevalent [3], caused mainly by a significant lower physical activity and higher weight decompensations [4,5]. Approximately 50% of persons with IDs perform a sedentary life style and 40% has been found to do low physical activity [6]. A recent review found that only 9% of people with IDs worldwide achieved the WHO´s minimum physical activity guidelines [7], despite meeting the physical activity guidelines was positively correlated with male gender, younger age, milder IDs, and living without supervised care. In the general population, a more sedentary lifestyle has be-come a pronounced problem in younger people [8], and it is a greater problem in youth with ID [9]. Low levels of physical activity could be due to barriers, such as scarcity of available resources and opportunities or a lack of motivation [10].

Physical activity is a modifiable risk factor for chronic diseases and an important way to improve health and prevent diseases [11]. Several studies have reported on the effects of physical activity interventions for people with ID on physical fit-ness indicators, such as balance, muscle strength, and quality of life [12]. Further-more, a review found a moderate level of evidence that sport-related activities seem to contribute to well-being and perception of social competence [13]. A multi-component intervention in Sweden to improve diet and physical activity in individuals with ID in community residences showed positive effects on levels of physical activity and work routines [14]. However, only adults with mild to moderate IDs were included, and effect sizes were small. A recent theory-based randomised con-trolled study of adults with all types of ID did not find any significant increases in levels of physical activity (steps per day) [15]. Furthermore, the results of a recent cluster-randomised study of older adults in the Netherlands showed marginal effects and substantial missing data, despite being well-prepared with a published protocol and using day-activity centres for the intervention [16].

Studies often include people with mild to moderate ID only, but the benefits for people with severe ID tend to be at least as good [14]. Motivational issues have been challenging, particularly for approaches oriented to sustain the effect after the intervention [13]. The main objective of the project *"Effects of physical activity with e-health support in people with intellectual disabilities"* is to enhance physical activity in youths and adults with IDs by means of motivational technology-based tools. As low physical activity is a determinant of health, and as increasing activity has positive effects on cardiovascular and psychosocial health, identifying effective interventions for use in everyday settings is of utmost importance. Studies conducted to increase physical activity in people with IDs are often non-randomised, in non-natural settings, and not theory-based and often exclude people with more severe IDs. Recent well-designed studies in this field have failed to demonstrate improved levels of physical activity in intervention groups. This paper describes the rationale and characteristics of three prototypes to support and motivate persons with IDs to increase their physical activity.

2 Materials and methods

The study will involve persons with all types of ID who perform low activity levels, as this target group has been previously identified to have the greatest chances of improving the fitness condition [16]. A person-centred physical activity (PA) programme is expected to increase level of fitness, mental well-being and social support, and improve health conditions such as blood pressure and functional strength.

Although previous studies have been theory-based, the person-centred focus could improve with the use of individual goalsetting [18] and we have designed the intervention in a natural setting to enhance the effect [19]. Staff involvement will be central. We also expect the systematic use of e-health with rewards and gamification to be beneficial [20]. In Norway, many persons with IDs have a smartphone they can use for tailored physical activity games, which has not been tested previously. Accelerometers have been used to examine physical activity and sedentary time patterns in related populations [21].

The project to which this position paper belongs defines three sub-objectives. First: to integrate theory with users´ needs to design a motivational e-health support in natural settings. Second: to investigate the effects of this physical activity programme in youth and adults with ID in a randomised controlled trial. Third: to increase research activity and national and international cooperation in this little investigated field.

2.1 Technology-based motivation

The technical contribution of the research project *"Effects of physical activity with e-health support in people with intellectual disabilities"* shall be the development of tools that can contribute to increased physical activity. Given the user-centred approach, we aim to take advantages of that many people with IDs enjoy the use of new technologies and multimedia and thus give them access to virtual and real environment through recorded physical activity. We plan to develop several applications that are able to record physical activity and provide real-time motivational feedback. Recorded activity will then be swapped into time to watch movies and TV. We aim at studying different reward and motivation mechanisms from computer games and tailor them to people with IDs.

2.2 User involvement from early stages

Users and user-organisations are involved in all parts of the project. To understand the users´ needs and to design effective health behavioural support tools, we will gather data from focus groups and individual interviews. Participants will be selected strategically.

Two focus groups will consist of six to nine participants who will be asked to discuss their opinion regarding the role of technology and behaviour change support. Users, relatives, staff and professionals will be involved to design an optimal enjoyable programme for increasing physical activity [19]. We will use thematic analysis to summarize the results and extract user needs and perceptions.

We wish in the current project to go a step further than just gather user input at the start of the project, and use Participatory design (PD). More specifically, we will use workshops and think-aloud-protocols in our lab and out in the participants daily environment. We will conduct individual interviews with participants after the focus group discussion. Later, these participants will be invited to think aloud while interacting with our prototypes and reflecting its ability to meet their needs.

2.3 Mobile technologies and gamification for motivating behaviour change

Despite the promise of mobile health (mHealth) and the explosion of fitness-related apps in markets, the vast majority of solutions are yet focused to a routine care basis and to record health and fitness-related data. Several studies have evaluated the effectiveness of mHealth interventions in specific clinical endpoints related to health promotion and disease worsening preventing [22]. Gamification and coaching techniques are also a promising feature of mobile health apps Sannino et al. [23] introduced the concept of a constant follow-up of the patient's performance along with continuous feedback and reward system according to the user behaviour and disease control.

In the scientific literature, there is a lack of work to create a rigorous process for design of mobile-based solutions for persons with IDs targeting a behavioural shift. Giunti proposed a model based on User-Centred Design (UCD) [24] for the design of mHealth solutions for chronic patients using a compromise between medical knowledge, Behaviour Change Technologies and gamification. Schnall et al. explored the use of Information Systems Research (ISR) framework as guide for the design of mHealth apps [25] as a way to promote a change in the users. Jia et al. defined a design framework for self-management mHealth solutions employing the quantitative Fogg Behaviour Model to enhance user's execution ability [26]. Those work used several participatory researching techniques but both including adults and children. Although authors identified the participatory techniques used in their work, no information regarding what type of technology was determinant for promoting a behaviour change, which limits its reproducibility in the context of IDs. To the best of our knowledge, no study has proposed a methodological framework to design context-aware and personalised mHealth solutions to support and motivate persons with IDs to increase physical activity habits.

3 Results

This innovative project results in a system composed of three different solutions which can co-exist and motivate people with IDs to increase physical activity on daily basis with the use of mobile phones, wearables and gamification strategies.

3.1 Used-centred design requirements

The thematic workshops with experts, parents and institution staff leaded us to define the baseline requirements of the system. This information was exchanged on meetings and contact through emails in the start phase of the project, but also during implementation to discuss features and decisions. This cooperation has provided valuable information on how to develop a system for this kind of users when it comes to design, content, and layout. At the meeting, the ideas for this project were presented through illustrations of the design and explanations from the authors. The attendants of the meeting were then allowed to give their opinion on what they thought about the ideas. The meeting resulted in constructive input to the project and new features that could be included in the application. It was also motivating to see that the user representants were positive and interested in the project.

Table 1. Summary of the system requirements based on experts opinions.

Scope Area	Requirement
Physical activity in persons with ID	Critical factors for being physically active are the support from parents and care-takers, to be able to show someone what is achieved, predictability, coping ability of activity, amusing and fun, medals and rewards. It is necessary with a clear correlation between reward and activity.
Intervention studies in persons with ID	Few intervention studies with ID and E-health and struggles with dropouts and missing data in studies. However, the presenter is favourable to that mobile health apps interventions can provide a significant effect on improving PA levels.
Motivation in persons with ID	Inner (joyful, meaningful, coping, etc.) should be preferred over external motivation (praise, money, threats, etc.) to get a long-term effect. To achieve a behavioural change takes a structured plan, support from caregivers and much effort.
User-friendly environment	It is important to achieve predictability and how the application should be able to express what is about to happen for an individual with ID or at least be helpful to do so. Use figures and icons to explain different activities and support audio.

Table 1 summarizes the main requirements of the system based on the opinions of experts. Some of the critical remarks were that e-health should provide amusement, be a tool that can show others the achievements performed and provide rewards that are related to the performance in an activity. An e-health tool should be easy to use, but not childish as it can appear stereotypical and insult some users.

3.2 eHealth based proposed solutions to increase physical activity

Physical activity will be measured using the mobile phones in-built accelerometers, wristbands and a bike-roller for in-door static physical activity. This input will be the basis for the game. Our approach provides primary rewards mechanisms including fun and achievement elements. Social interaction has been identified as a powerful reward, so opportunities for collaborative missions are included.

The game needs to offer progressive mastery experiences, which again means that it will have to be tailored to the user. Care workers involved in the project helped to tailor the physical activity game to the individual´ goals and resources and specifics of the intervention will be developed iteratively in close collaboration with users.

The system provides three main solutions: Guided in-door bicycle exercise for aerobic mild intensity exercise, which makes use of a tricycle and a bike-roller connected through Bluetooth to a tablet; an augmented-reality based game for out-door moderate exercising and a coaching app for promoting in-door workouts for moderate to hard exercises.

Proposed solution #1: Guided in-door bicycle exercise. The first solution comprises hardware and software modules to track and record the amount (intensity and time) of physical activity on indoor bikes. To this end, the solution can use two different bikes: (1) an outdoor bike mounted on a Tacx roller, and (2) an indoor, stationary exercise bicycle / ergometer bike. The goal is to detect the activity performed on the bike and transfer the activity measurement to a tablet- based entertainment system, which will react to the performance of the user in the bike and will show different multimedia records (real routes, virtual routes or media).

This solution will provide continuous feedback during realization of the physical activity. Therefore, the designed setup will monitor parameters such as speed, cadence and power. The setup is capable of transmitting data wirelessly (in the current prototype is Bluetooth LE) and in a real-time to a control unit (e.g. smartphone/ tablet). The user is rewarded when selecting heavy load on the bike and for cycling for longer periods of time, proportionally. The graphical user interface contains computer game features connected to the hardware of the bicycle, so for example, by cycling through a landscape with computer game elements, receiving rewards in the form of symbols, animations, sounds, etc., during the exercise.

The first prototype uses a Tacx Flow Smart trainer (Upside left corner in Fig. 1) that support Bluetooth Low Energy and Ant+ connection. This trainer measures speed, cadence, and resistance; and it is possible to adjust the resistance on the power wheel. A cadence is a standard unit of measurement for bike trainers, and it means the frequency of the pedal turns when cycling. This trainer suits most type of bikes with a power wheel with a size between 26” and 30”. For testing of the first solution during development, we borrowed a three-wheel bike from NAV, a welfare institution in Norway among other services provide equipment for those who have special needs (https://nav.no). Using a three-wheel bike is that it will appear steady and stable to ride.

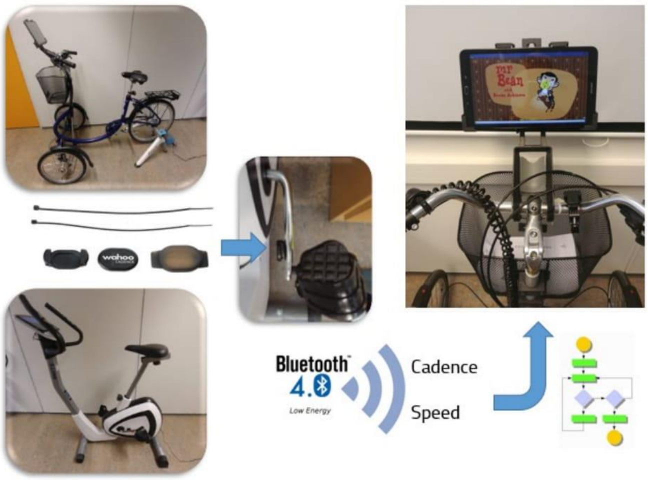

Fig. 1. Set up of the in-door bycycle based activity monitor.

The second prototype is mounted on an U.N.O. Fitness ET1000 (https://www.fitshop.no) ergometer bike (Down-left corner in Fig. 1). The bike comes with an embed computer that measures speed, resistance, and distance during a training session. To make the setup of the system more straightforward and scalable we decided to use a separate Wahoo cadence sensor which supports Bluetooth Low Energy (BLE) connectivity (central part in Fig. 1). The Wahoo sensor uses the FTMS protocol through BLE, the same as the Tacx Smart Flow trainer which makes the connection implementation simpler as it can be used in both solutions.

When the application starts (Upside-right corner in Fig. 1), a display showing the status of the current week activity time performed. From the start page, there is a navigation option to settings, video mode, game mode and history of activity. Video mode and game mode are the two options for activity sessions this system provides. After an activity session is finished, the activity time is added to the total activity time of the current week.

Proposed solution #2: Guided out-door exercise. The second solution provides a tool for people with intellectual disability to make them more physically active in mild to moderate intensities (walking and hiking). The technical solution is a mobile application that can be used anywhere and is tailored for a user group that previously have had no specially tailored solution with the same objective.

The app tacks the amount of physical activity in outdoor walking, hiking, etc. by means of step counters and GPS-tracking. This information is then transmitted to the entertainment system, which adapts the environment and reacts according to the pre-set preferences.

The gamification technique is based on augmented reality and proposes the user to chase virtual animals into a real environment (recorded with the mobile phone built-in camera). The user can select four different farm animals displayed through user-friendly avatars (Fig. 2), which will be distributed into the user surroundings, so they can walk towards the animal to 'collect' it.

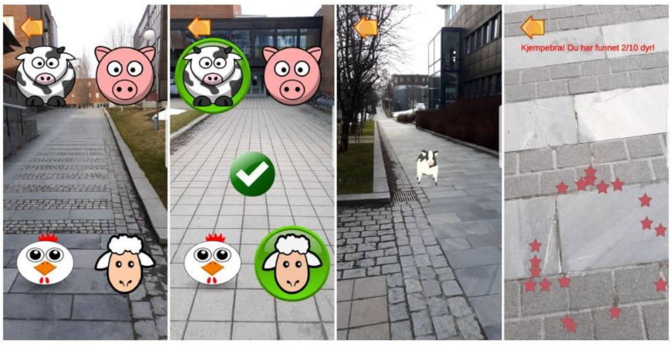

Fig. 2. Graphical user interface of the guided out-door exercise app.

Once the animal is collected, they will be prompted with a supportive message on the screen, and a voice recording encouraging and recognizing success. In addition, the screen has confetti bouncing on it, and a medal will be displayed containing the animal they reached. The setup is able to monitor parameters such as intensity, type of activity and time, and in future extensions it will transmit recorded data to a control unit / cloud-based application.

Proposed solution #3: Guided mild workouts. The third solution provides a coach-based mobile application to promote physical activity in people with ID by means of a three-dimension avatar. This virtual character is customizable so that each user can make it look like he/she wants, so that connection between the user and the character may lead to higher levels of engagement and them wanting to use and interact with it. Once the avatar is created and customized, the app provides a set of basic workouts and pre-set combinations of them, so the user can choose to perform specific or complete routines.

When selecting an activity, the user interface shows the activity animation to make it clear to the user what it entails (Fig. 3). This is because it can be difficult to explain an exercise activity without any type of movement. Text To Speech features are also included in the app, to help the users understand context and functionality of the app which can otherwise be hard to convey using only the visual user interface. The app includes reminders by means of notifications to sustain the adherence to work out routines in case of periods of inactivity.

Fig. 3. Screenshots of the guided workouts app and the avatar.

4 Discussion

E-health provides a wide range of possibilities for monitoring and motivating people in the self-management of chronic illnesses. In this position paper we present the design and development of prototypes of game-based eHealth solutions for behaviour change and health promotion by influencing physical activity. Motion sensor games have been explored and found to be promising in people with ID.

Our approach to move out of the lab and into actual use included a first stage for meeting user's needs. Participatory design and agile development have been applied in this project to deliver a system based on three solutions to promote, motivate and maintain physical activity in people with IDs. These solutions may contribute to the physical activity of the user group of persons with intellectual disability and also act as ring effect their physical and mental health, as well as improving their health and lifestyle situation.

Once these applications have been assessed and improved in beta-tests, they will be used into a randomized-control trial to assess the effect of eHealth in direct physical activity indicators and secondary health endpoints.

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Appendix 5

Interview for test at daycare institution, with answers:

Intervju om test av innendørs sykkelsystem

<u>For spørsmål om brukerene. Bruker 1, bruker 2 og bruker 3</u>

Hvor vant var brukeren med å bruke teknologiske hjelpemidler (nettbrett, andre)?

Hvor vant er brukeren med å sykle?

<u>Generelle spørsmål.</u>

Var det noe du eller brukeren savnet med systemet?

<u>Effektiviteten (estimert)</u>

Hvor lang tid brukte brukeren på å starte en treningsøkt? (fra personen kommer til sykkelen, til personen kan begynne å sykle)

Var det mange problemer under veis i bruken av sykkelsystemet? Fikk brukeren til å starte en treningsøkt alene?

Spørsmål om sykkelappen. Tilfredshet.

Disse spørsmålene er for å høre hva du tror om hvordan sykkelappen er å bruke for personer med psykisk utviklingshemming.

1. **Jeg tror personer med psykisk utviklingshemming vil bruke systemet jevnlig.**

Svært uenig - 1 2 3 4 5 - Svært enig

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2. **Jeg tror en person med psykisk utviklingshemming vil synes systemet er unødvendig komplisert.**

Svært uenig - 1 2 3 4 5 - Svært enig

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3. **Jeg tror en person med psykisk utviklingshemming vil synes systemet er lett å bruke.**

Svært uenig - 1 2 3 4 5 - Svært enig

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4. **Jeg tror en person med psykisk utviklingshemming vil trenge støtte fra personell for å bruke appen.**

Svært uenig - 1 2 3 4 5 - Svært enig

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5. **Jeg tror en person med psykisk utviklingshemming vil synes de forskjellige delene av systemet henger godt sammen.**

Svært uenig - 1 2 3 4 5 - Svært enig

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6. **Jeg tror en person med psykisk utviklingshemming vil synes det var for mye inkonsistens i systemet. (Det virket ulogisk)**

Svært uenig - 1 2 3 4 5 - Svært enig

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7. **Jeg tror en person med psykisk utviklingshemming vil lære seg fort å bruke denne appen.**

Svært uenig - 1 2 3 4 5 - Svært enig

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8. **Jeg tror en person med psykisk utviklingshemming vil synes appen er vanskelig å bruke.**

Svært uenig - 1 2 3 4 5 - Svært enig

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9. **Jeg tror en person med psykisk utviklingshemming vil føre seg komfertabel med å bruke appen alene.**

Svært uenig - 1 2 3 4 5 - Svært enig

10. Jeg tror en person med psykisk utviklingshemming må ha en omfattende opplæring for bruke appen.

Svært uenig - 1 2 3 4 5 - Svært enig

Appendix 6

Written consent for testing at day-care institution:

Forespørsel om deltakelse i forskningsprosjekt

"Forbedre fysisk aktivitet med hjelp av teknologiske hjelpemidler hos personer med psykisk utviklingshemming"

Dette er et spørsmål til deg om å bidra til et forskningsprosjekt som utvikle elektroniske verktøy for å fremme fysisk aktivitet hos personer med utviklingshemming.
I undersøkelsen vil vi kartlegge brukervennlighet av tre mobile treningsapper utviklet av masterstudenter ved UiT Norges Arktiske Universitet. Det er tre forskjellige apper hvor alle har som mål å gjøre aktivitetene gøy å utføre.

Ansvarlige for undersøkelsen er

Navn	**Rolle**	**Mail**	**Telefon**
Audny Anke	Prosjektleder	audny.anke@uit.no	95936333
Gunnar Hartvigsen	Professor	gunnar.hartvigsen@uit.no	77644049
Henriette Michalsen	Doktorgradsstipendiat	henriette.michalsen@uit.no	
Marius Wiik	Mastergradsstudent	marius.wiik@uit.no	40000478
Valter Berg	Mastergradsstudent	vbe013@post.uit.no	97642580
Vebjørn Haugland	Mastergradsstudent	vha044@post.uit.no	99129279

Hva det innebærer å delta

I undersøkelsen vil du prøve èn av de tre applikasjonene. Vi er interessert i hva du synes om appen og hvordan den var å bruke. Dette kan du fortelle en av personalet eller en i familien. Vi vil også spørre personalet om hva de synes om treningsappen

Frivillig deltagelse

Det er frivillig å delta i undersøkelsen og du kan når som helst trekke deg uten at du behøver å oppgi grunn. Dersom du ønsker å delta undertegner du arket med samtykkeerklæring.

Hva skjer med informasjonen om deg?

Vi vil bruke resultatene fra spørreundersøkelsen til å evaluere designet til treningsappene for å finne ut hva vi kan gjøre bedre. Disse resultatene vil bli diskutert i vår masteroppgave. Ingen identifiserbar informasjon vil bli samlet inn eller inkludert i rapporten. Etter at masteroppgaven er levert 1. Juni vil alle notater hvor det er resultater fra utprøvingen makuleres på en forsvarlig måte.
Mer informasjon kan fås ved henvendelse til en av de ansvarlige for undersøkelsen.

Samtykke til deltagelse i prosjektet

Jeg er villig til å delta i prosjektet

Signatur:

Sted og dato **Deltakers signatur**

____

Deltakers navn med trykte blokkbokstaver

Stedfortredende samtykke:

Som nærmeste pårørende til ………………………………………… (fullt navn) samtykker jeg til at hun/han kan delta i utprøvingen.

Sted og dato **Pårørendes signatur**

Pårørendes navn med blokkbokstaver

Appendix 7

Written consent, simple version:

Deltakelse i Forskningsprosjekt

Du skal:

- Prøve en treningsapp
- Si hva du synes om appen

Det er frivillig å delta og du kan når som helst trekke deg.

Vi vil bruke tilbakemeldingen du gir når vi vurderer appen du har prøvd.

Det vil ikke bli lagret noe data som kan knyttes til deg.

Jeg vil delta på utprøving av utstyr

Signatur:

Samtykke til deltakelse i studien