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Activity Game Avatar: A interactive exergame for people with intellectual disabilities

Physical activity combined with motivational mechanics in a game-environment

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Stack your failures, eventually you will reach your goal.

“Do it badly; do it slowly; do it fearfully; do it any way you have to, but do it.”
–Steve Chandler

“Actions have reactions, don’t be quick to judge.
You may not know the hardships people don’t speak of.”
–Keith Edward Elam

Preface. *Living a happy and healthy life, both mentally and physically, is directly connected to maintaining regular physical activity. In society, we are surrounded by technology designed to help us maintain this healthy lifestyle, usually in the form of mobile devices such as smartphones as smartwatches, but are we including everybody?*

A part of society that is often forgotten or overlooked regarding both accessibility and usability is individuals with intellectual disabilities. Recent studies show a decline in physical activity and exercise, with growing concern towards obesity and other health-related problems associated with a sedentary lifestyle. The thesis explores the possible health benefits of a game-inspired and avatar-based exergame for people with intellectual disabilities. The user I able to participate in exercises either alone or with friends. By utilizing motivational mechanics such as point- and reward systems, we hope to create an engaging environment that promotes a more healthy lifestyle. Being such an important subject, this became my inspiration and goal for the thesis.

The 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 driving force. This project is the second installment and a continuation of Marius Foshaug Wiik's master thesis, "AGA: A Game-Inspired Mobile Application for Promoting Physical Activity in People With Intellectual Disabilities" which concluded in June 2019. In this installment, the application has grown in both functionalities (multiple users), motivational mechanics (reward systems) and content in general.

Throughout this thesis duration, there have been many ups and downs; I want to thank my supervisor, Gunnar Hartvigsen. Without your guidance and belief in me, this would not have been possible. If there ever was a problem or question in need of answering, you were there to help me out. Starting out with the weekly meetings, I sometimes wondered if it was that necessary. Looking back, I am very happy for them, as they proved to be a great bunch of people and a valuable source of knowledge and feedback. I also want to thank the PA-ID project group that attended the meetings, all my co-supervisors Audny Anke, Letizia Jaccheri, Santiago Martinez, Susanna Pelagatti, Keiichi Sato, Javier Gomez Escribano, Antonio Martinez Millana, Mirek Muzny and Andre Henriksen, and Erlend Johannessen. The diversity within the group made for fantastic support on whatever problem or subject of interest in regards to the thesis.

Last but not least, I would like to thank my family for their endless support; It has been a challenging six years. I can always count on your support in all I do, and for that, I am very fortunate.

Thomas Eilertsen - Tromsø, Norway, March 2021

Abstract

Statistics from the World Health Organization (WHO) show clear indications that some groups in society have more significant struggles than others getting the recommended amount of physical activity. One of these groups is people with intellectual disabilities, which have different functioning resulting in different needs in terms of facilitation, accessibility, and usability. Many within this group have a sedentary lifestyle, often resulting in health problems such as obesity, diabetes, and cardiovascular disease. The purpose of this thesis is to explore the possible health benefits of a game-inspired and avatar-based exergame for people with intellectual disabilities. This thesis extends research into the exergame application Activity Game Avatar (AGA) started in 2019.

Because of the very nature of intellectual disabilities, collaboration with experts within the field (PA-ID group) and literature review is imperative to achieve the goals set for this thesis. Weekly meetings were held to have a constant flow of input, feedback, and discussion related to the AGA application development. Within the PA-ID group are experts on information technology, psychology, assistive technology, user-centered design, and intellectual disability.

While AGA is still in a prototype-phase, current results and feedback show great promise as a motivational tool that could help engage its users in physical activity. The COVID-19 pandemic made real-world testing difficult; the solution was an introduction of the application at Kvaløya VGS with special lecturers and supervisors. As with the PA-ID group, feedback is positive, with some elements that could be refined or improved in the future.

In this thesis, the AGA application has grown tremendously in functionality, content, and motivational mechanics. The application now has a broader and more complete environment with a depth more engaging for its users. It offers features like exercises, collectable rewards, personal progression, and entertainment in the form of an exergame for mobile devices.
Future aspects explored by not completed are online connectivity, health data collection, and more exercise features at a time where testing can be conducted more thoroughly.

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List of Abbreviations

ADD attention deficit disorder

AGA activity game avatar

ASD autism spectrum disorder

AT assistive technology

GLD general learning disability

ICT information and communications technology

ID intellectual disability

IDE integrated development environment

IOS international organization for standarization

IS interactive Systems

PA physical activity

PA-ID effects of physical activity with e-health support in individuals with intellectual disabilities (Research project this thesis is part of)

SUS system usability scale

TTS text-to-speech

UI user interface

VRS volere requirements specification

WHO world health organization

1 Introduction

The disability is not the problem, The accessibility is the problem! -Mohamed Jemni

1.1 Background

In the last two decades, there has been an explosive increase in awareness related to exercise and healthy living. An increase in physical activity (PA) combined with a less sedentary lifestyle (watching TV, sitting by the computer, or mobile devices) has proved to significantly better both mental and physical health if done regularly [1].
By participating in PA on a regular basis, one significantly lowers the chances of having a wide variety of health problems ranging from stress, heart disease, rheumatic conditions, and obesity.
The Norwegian Directorate of Health recommends 150 minutes of moderate PA per week, or 75 minutes if the PA is considered more intense [2]. New general health recommendations stated by the world health organization (WHO) recommend 150-300 minutes if moderate, and 75 - 150 if the activity is considered intense. [3].
Several studies indicate that both young and adults with ID struggle to get the necessary amount of physical activity [4].
It is estimated that somewhere between 1-2% of the world's population has some form of ID. It is characterized by significant limitations in both adaptive

behavior and intellectual functioning, impacting a range of everyday social and practical skills [5].

In a study done by Temple [6] it is estimated that only 20-30% of adults with ID get the recommended amount of physical activity while another cross-sectional study indicated in the low 9% [7].
This, together with indicators that low amounts of PA increase the mortality rate in adults with ID is a clear sign that society has to make a greater effort including and facilitating for this particular group.
Additionally, many within the group have a variety of health complications [8]; one example is individuals with Downs syndrome, which are more likely than others to have congenital heart defects, leukemia, and various types of neurodegeneration. Other conditions can be problems with eyesight with increased risk of cataracts or refractive errors (near- and far-sightedness, degeneration of cornea) [9].

With technology rapidly evolving and becoming part of everyday life, this project aims to increase motivation for PA in the form of an application for mobile and tablets. Here the user engages in exercise within a game environment containing motivational factors, rewards and competition which show promise in recent studies by Michalsen et al. [10].

These are the primary reasons and motivations behind the Project effects of physical activity with e-health support in individuals with intellectual disabilities (Research project this thesis is part of) (PA-ID) and all related sub-projects [11, 12, 13]. In an effort to turn the tide, this project introduce new approaches that will benefit people with ID by facilitating and making modern technology like mobile devices more accessible for this group.

1.2 Context

The AGA application is developed as part of a sub-project to PA-ID, and is funded by Helse Nord. The main objective of the study is to enhance PA in youths and adults with ID.
The project group has a strong interdisciplinary environment with background in informatics, health and intellectual disability. Leader of the project is Professor and Chief physician Audny Anke (UIT/UNN), and is assisted by Professors Gunnar Hartvigsen (UIT), Letizia Jaccheri (NTNU), Susanna Pelagatti (UNIPI) and Keiichi Sato (IIT, Chicago). Additional members consist of Dr Javier Gomez Escribano (UAM, Madrid), Dr. Professor Santiago Martinez (UIA), Dr. Antonio Martinez Millana (UPV, Valencia), Research scholar Andre Henriksen (UIT), Research scholar Erlend Johannessen (UIT) and Avd.ing. Mirek Muzny

(UNN).

Recent studies found that only 9% [7] of individuals with ID are getting the WHO minimum physical activity guidelines [3]. There are several factors that contribute to these statistics; many people with ID live sedentary lifestyles because of their conditions.
Other factors that are contributing to this negative trend is the lack of accessibility provided, essentially excluding this group for participation in activities related to PA [14].

The aims of the main PA-ID project are three-fold, stated as follows:

- **To integrate theory with user's needs to design a flexible person-centered physical activity prototype using motivational e-health support in natural settings.**

- **To investigate the effects of this physical activity program in youth and adults with ID in a randomized controlled trial.**

- **To increase research activity and national and international cooperation within the field of intellectual disabilities.**

This is the second installment of the AGA application following the work and research done by Wiik [15]. The first installment of the AGA application included much of the core functionality for an exergame, allowing the user to do different exercises, gaining points, and rewards. Since this prototype included good core features and had so much potential, it was natural to try and complete the vision in this second iteration.

1.3 Scope and research problem

In the development of any application, ease of use is a crucial factor in order to deliver a good experience for the end-user.
The application should be easy to understand and intuitive in use, having usability and accessibility as the highest priority [16]. With the adaptation of smartphones and tablets into everyday life, the technology and amount of research within the field of human-centered design and interactive Systems (IS) is quite substantial.

But what happens when the end-user has very different needs than the average consumer? Statistics from WHO estimates that around 1-2% of the world's population have ID, meaning they may have different needs and preferences

that are not taken into consideration when developing applications for mobile devices.
This part of the population is in the great minority and often forgotten when referring to application use and design; how can we make a good and accessible exergame for people with ID?

> ***How can modern technology such as mobile devices help promote physical activity in youths and adults with intellectual disability?***

Three very recent articles written by Michalsen et al. [10, 11, 17] and Berg et al.2019 [12] at UIT take a closer look at the use of technology and motivational factors in an effort to improve PA among individuals with ID. This is the foundation for the AGA application and its continued development.

With the development of the AGA application, the main reseach problem of the project is to see if a modern and technological approach to exercise can help with motivating user's into getting the recommended amount of PA in their daily routine.

Main research problem :

- **How can we create an avatar-based game application that promotes physical activity through motivational mechanics that is suited for people with intellectual disabilities?**

Sub problem #1 : A deeper look at design, accessibility, and motivational mechanics:

- **With the application in use, how do we make it engaging enough for the user to return on a regular basis?**

Sub problem #2 : Generating reliable research datasets from the users in this environment.

- **With the application in use and returning users, how do we collect health data without compromising the user experience?**

1.4 Assumptions and limitations

In its infancy, the AGA application wanted to facilitate all individuals with ID, but because of the very different levels of functioning within the group, this was considered not feasible [18, 5]. Instead, the application was directed at the largest portion of the group, trying to target mild to moderate levels of ID where the cognitive capabilities are higher [5].

Individuals with mild to moderate ID have higher functioning [5, 19, 18], and will have increased capacity for learning new concepts, verbal communication and participation in an organized activity. These are all to some degree necessary as the user might need to operate a mobile device running the AGA application.

In this installment of the AGA application, the primary goals are to complete or complement the current core functionality. The focus includes multiple user integration, a broader reward-system that utilizes motivational mechanics—additionally, functionality for the user to track his own progression and collected rewards in an understandable manner.

Looking at the previous work done by Wiik [15] it would not make sense to deviate from the current focus group or drastically change the core functionality of the application, but rather improve on it and make the application a reality. Many great features like text-to-speech (TTS), rewards, and a working avatar-environment open for possibilities to further refine and add to the content of the application. This could be but is not limited to multiple users, additional-exercises, and motivational factors.
Focus is directed at finishing the core functionality already put in place and adding some new features to increase the usability and motivational factors. With the necessary functionality in place, connection to a online server for storage and persistence may be feasible. This would allow collection of health-data in future projects and integration into wearables like Fitbit and android watches.

1.5 Contributions

This thesis makes the following contributions:

- **A motivational exercise application for mobile devices that is specifically designed for people with intellectual disabilities. Since it is developed for phones and tablets, it makes for easy integration into everyday life.**
- **A modern approach to PA in the form of an avatar-based game, combining exercise with motivational mechanics often found in game environments.**
- **Multiple users allow for a competitive environment containing motivational features such as points and unlockable rewards.**

1.6 Outline

The remainder of the thesis is structured as follows:

Chapter 2 - Technical background Presents theoretical information about ID in general; It also describes the different tools used in the development part of the thesis.

Chapter 3 - Method Presents the research methods used in this project.

Chapter 4 - Requirements specification Defining the requirements more clearly.

Chapter 5 - Design and implementation Explain the implementation and design choices made in the AGA application.

Chapter 6 - Testing Explain the internal workings of the implemented features in the AGA application.

Chapter 7 - Discussion What has been achieved, what can be improved upon.

Chapter 8 - Conclusion and future work Current state of the project as a whole.

2

Technical Background

2.1 Intellectual disabilities

The global population exceeded 7.7 billion in 2019; it is estimated that about 1-2% of have some kind of ID [20].
Often referred to as general learning disability (GLD), is a generalized neurodevelopmental disorder that is characterized by below-average intelligence (IQ ranging from 70 to low 20) and additional problems with adaptive functioning [19].
In the UK both ID and borderline ID is referred to as Learning disability while WHO, Europe, and the US use the terminology Intellectual disabilities. The WHO defines it as a "significantly reduced ability to understand new or complex information and to learn and apply new skills" [21] that often occur during the developmental period resulting in some degree of cognitive impairment.
This has an adverse effect on grasping new concepts, learning, and applying new skills, which is necessary to cope independently.

In order to fall within this definition, three requirements [18] must be true:

- The cognitive ability must be significantly impaired, while Intellectual functioning should be estimated at less than 70 IQ [5].
- Deficits or impairments in adaptive functioning, either in communication, social skills, personal independence or everyday functioning [5].
- Onset of disability should happen before the age of 18.

In Norway, we have an estimated 80 000 people living with some form of ID based on the global statistics [20].
The diagnosis might vary depending on the level of cognitive impairment, ranging from mild to profound.
Because of the strong nuances within the needs and functioning that individuals with ID have, solutions and interventions have to be tailored to the individual.
Current method divide ID into four degrees based on IQ, though this may change in the future due to critique and research arguing its validity [18].

- **Mild ID: IQ 69-50**
- **Moderate ID: IQ 49-35**
- **Severe ID: IQ 34-20**
- **Profound ID: IQ 20 or less**

The causes for ID are many, happening both before, during, and after birth. In cases happening before birth, there are often complications connected to the development period. While cases after birth can be a result of infections, illness or injury [5].
Consequently, the disability includes chromosome abnormalities, metabolic diseases, congenital disabilities, and disease connected to pregnancy [9]. In addition this group often suffer other problems due to the nature of ID, this could be disorders like autism spectrum disorder (ASD), epilepsy, attention deficit disorder (ADD) and physical disability. In the more severe and profound cases, the chances of having additional disorders are even greater [9].

2.2 Motivational game mechanics

For the sake of clarity, in this thesis the word motivational mechanics is used in regards to ingame interaction or functionality that is engaging to the user and promotes further participation in the application. While game mechanics is a established term, motivational mechanics are only mentioned as part of it. For simplicity the terminology motivational mechanics will be used as it better describes the purpose of the functionality. In figure 2.1 below, possible motivational elements included in AGA is illustrated.

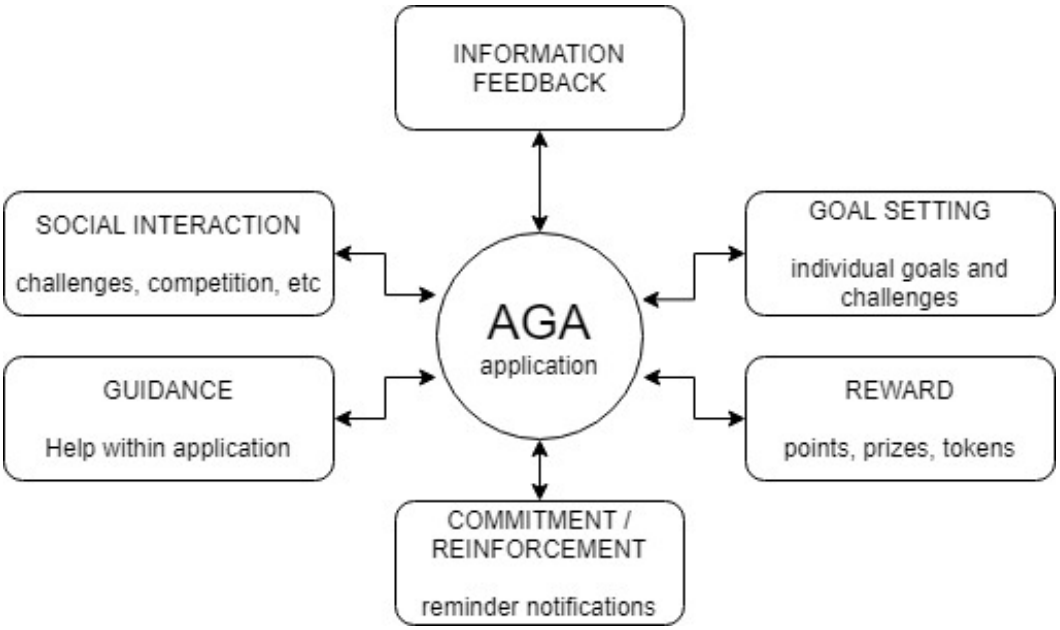

Figure 2.1: Potential motivational elements in AGA

2.3 Exergaming

Exergaming or exer-gaming is a terminology commonly used for games that require the user to participate in either regular exercise or some other form of physical activity. These games are created in an effort to make gaming a more healthy activity [22].

Figure 2.2: Exergaming: A new step toward fitness, Harvard Health [23].

These can often incorporate technology such as tracking of movement; other features might be monitoring of heart-rate and duration of exercise, just to name a few [24].
This genre has shown great promise and is credited for new approaches to gaming by introducing physical activity as a part of the game and promoting a more active lifestyle.
As with any health beneficial exercise, it is imperative that the user continues doing the exercises regularly to have the full health benefits. Because of this, there are two very crucial factors to exergames: How effective and entertaining the game is as a motivator, and the quality of the physical activities exercised within the game [22, 24].

Lastly, it is important that the user achieve actual health benefits from the exergame. Hence making it important to take into account certain factors [25]:

- It should be engaging with the user.
- It should require both concentration and be challenging.
- It should include skill-developing factors (balance, strength, etc.)
- It should be intuitive and have easy to understand goals.
- It should give feedback on progression.

2.4 State of the Art

In order to develop an application for a very specific end-user, it is imperative that literature regarding said subject is thoroughly reviewed. This is to establish knowledge about what has been done, including aspects that may or may not show promise. A state-of-the-art literature review is conducted to establish the required knowledge of the subject in order to achieve good results.

2.4.1 Data sources

The following databases were queried for the literature review:

- PubMed[14]
- Scopus[50]
- IEEE Xplore[12]
- Science Direct[57]
- ACM Digital Library[110]
- Games for Health[57]

2.4.2 Criteria for exclusion

In order to exclude literature some criteria had to be met.

- The literature had to be English.
- The literature must be available and not behind a paywall.
- The literature had to include physical activity combined with exergames.
- The literature had to include motivational or behavior change.
- The literature had to be published in 2018 or later.

2.4.3 Search Scope and inclusion criteria

The literature review was performed in November and Desember of 2020 with a quick recap at the end of the thesis in January, 2021. By creating a query containing the desired parameters using logical operators it was possible to do a wide search within each database.

The query created is designed in tree steps:

- The literature had to include intellectual disability (intellectual disability, down syndrome, autism)
- The literature had to include the gaming aspect (gamification, video game, exergame, app, avatar)
- The literature had to include the exercise aspect (physical activity, exercise, fitness)

The query created tried to include the most common words and aspects wanted in the review. Below is the query used in most of the cases (some databases require less operators).

("intellectual disability" OR "developmental disabilities" OR "autism" OR "downs syndrome") AND ("serious game" OR "exergame" OR "video game" OR "gamification" OR "application" OR "app") AND ("physical activity" OR "fitness" OR "exercise" OR "workout" OR "avatar")

In the screening process the remaining literature is reviewed based on:

- Title of publication.
- Abstract of publication.
- Content of publication.

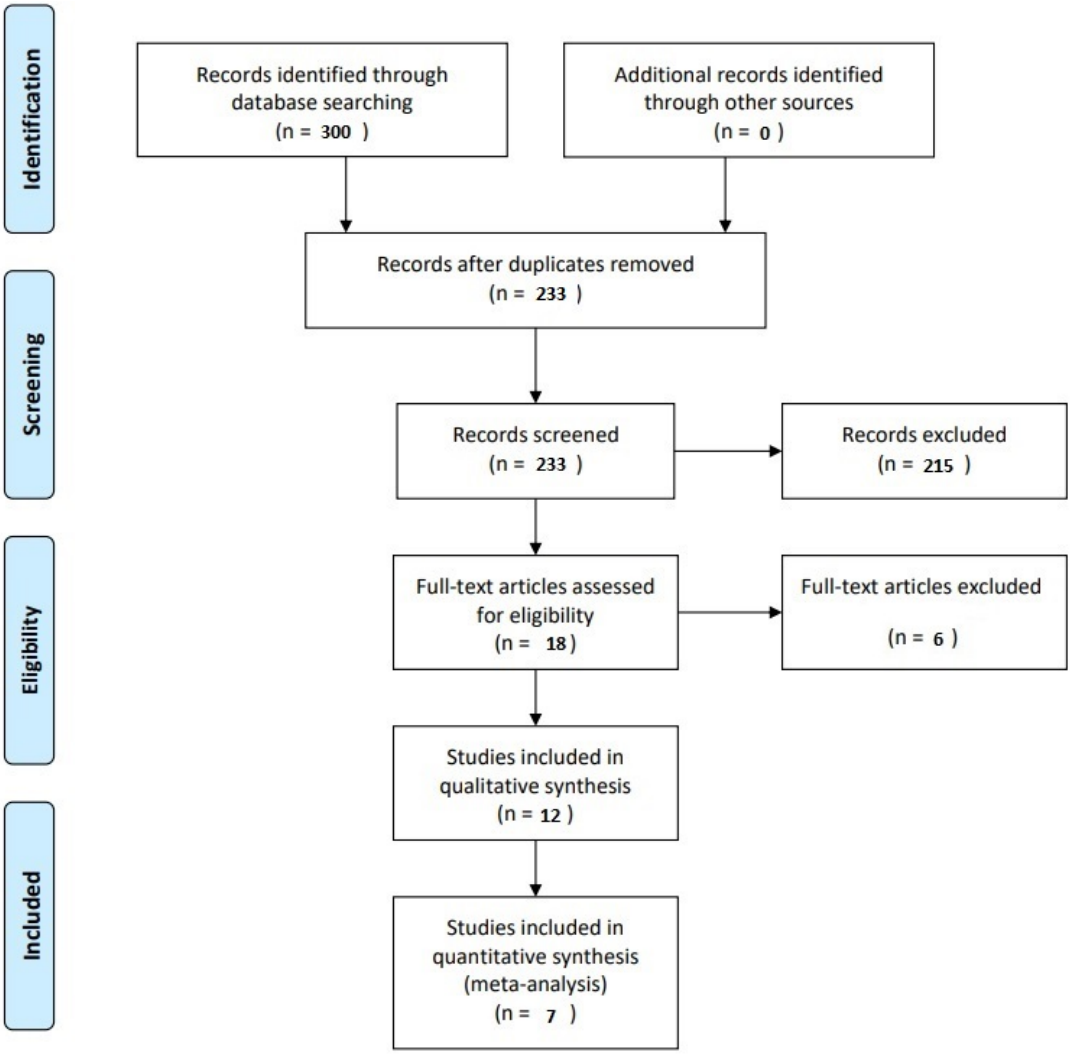

Figure 2.3: PRISMA flow diagram.

2.4.4 Results

Below is the literature that passed the eligibility and screening process. The literature only contains new material released in the time period between 2018 and 2020, this is done to minimize the amount of duplicated material already reviewed in the first installment of this project.

Paper/Author	Target group	Game/topic	Results
Alarcon et al. 2018 [25]	Individuals with ASD	Designing games for people with ASD	Strategies used in educational activities could translate well into digital games. Reinforcement, Token economy, prompting, shaping, modeling, chaining and task analysis, structure and transitions, breaks, errorless learning, and incidental teaching all show promise if done correctly.
Gamage et al. 2018 [26]	individuals with ID	Introduction of visual characters / avatars in serious games ID	Introducing visual characters or avatars can be effective as a learning aid, hightening engagement and retention of knowledge.
Fang et al. 2018 [27]	individuals with ASD	Effects of exergames on physical and cognitive functions in individuals with ASD	Individuals with ASD reported significant improvements in physical fitness, executive function and self-perception after exergame interventions. Exergaming also stated increase in participation in moderate and vigorous PA.
Haugland et al. 2019[28]	individuals with ID	serious mobile exergame for people with intellectual disabilities, to help people with intellectual disability be more physically active.	Participants with ID initially had some difficulties understanding the the AR concept, but once this threshold was overcome it proved both fun and challenging. The Application still in development.
Kim et al. 2020 [29]	individuals with ASD	Puzzlewalk, theory-driven PA game.	Focuses on what it takes to motivate, behavior change, self-monitoring, rewarding of behavior. Effects of feedback and goal setting.
Michalsen et al. 2020 [10]	individuals with ID	Family members and health care workers' perspectives on motivational factors for PA.	Motivation could be promoted on the individual level by fun, mastery, social setting, technology and knowledge about health behaviours. On a interactional level individuals were more motivated if the interaction was featured by competition, joint activities, predicatability and the use of rewards.
Berg et al. 2019 [12]	individuals with ID	Increasing physical activity for individuals with intellectual disability through indoor bike cycling and exergaming.	Setting up a stationary bike connected to an entertainment system is a effective way 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.

2.5 Application reviews

In the first installment of this project, a substantial amount of background research was conducted in a systematic review by Wiik [15] in order to establish what was considered state-of-the-art within exergames aimed towards people with ID.
The systematic review's objective was to find earlier efforts at a technology that was designed to motivate people with ID into a healthier lifestyle. The requirements were that the implemented software or hardware had gamification and motivational mechanics aimed towards PA. Below are the two best candidates from Wiik's [15] application review, with two additional candidates from the current application review.

App #	*App Name*
1	Boo - 3D Avatar & AR Chat (Android / iOS)
2	Burn Your Fat With Me (Android / iOS)
3	HealthyHeroes (iOS)
4	Female Workout - Lose Weight in 30 Days (Android / iOS)
5	UFit App (Android / iOS)
6	Just Dance Now (Android / iOS / Playstation)
7	UNICEF Kid Power (Android / iOS)
8	GoNoodle - Kid Movement & Mindfulness Videos! (Android / iOS)
9	Sworkit Kids - Fitness Meets Fun (Android / iOS)
10	Choiceworks (iOS)
11	Proloquo2Go (iOS)
12	FTU (Android / iOS)
13	FunDoRoo (Android / iOS)

Figure 2.4: Applications reviewed.

The review [15] concluded with thirteen candidates where only two were directed at PA for people with ID. These were FTU (#12) and FunDoRoo (#13) [30, 31].

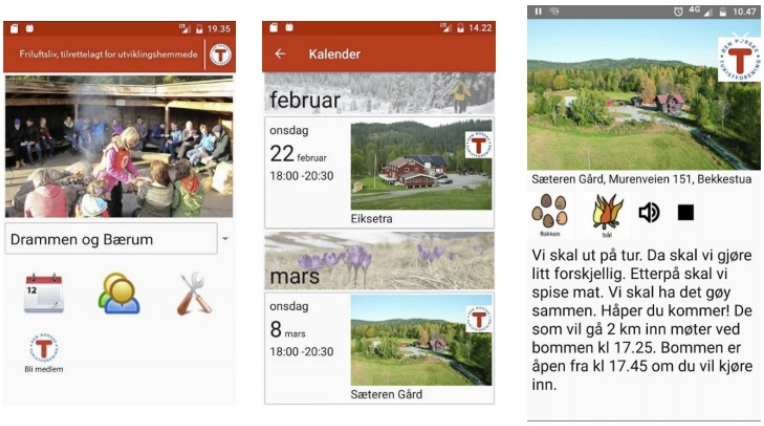

Figure 2.5: FTU, the norwegian hiking application [31].

FTU is a Norwegian hiking application that is designed for people with ID in mind, the design is easy to understand, it incorporates calendar functions and more [31].

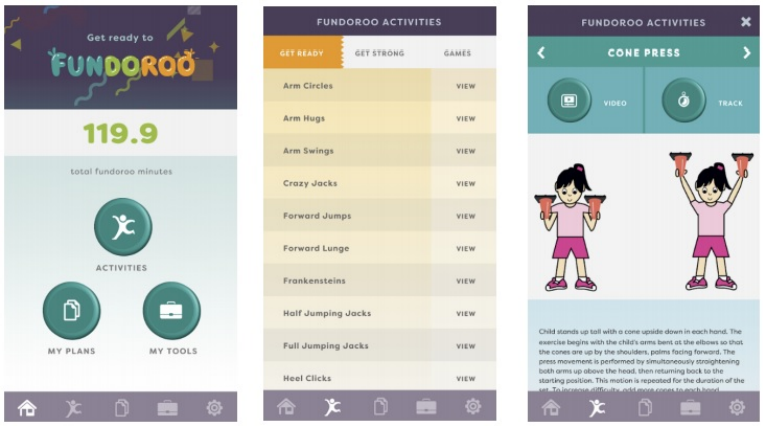

Figure 2.6: FunDoRoo, exercise with guidence [30].

FunDoRoo [30] is a application with a multitude of physical activites (jumping jacks, heel clicks, etc) developed to improve motor skills and PA for people with ID.

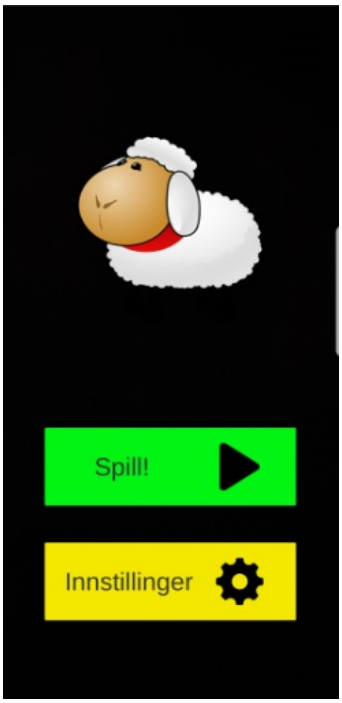

Figure 2.7: A pokemon-go inspired exergame for individuals with ID.

Figure 2.8: Capture animals through augmented reality.

Dyrejakten [28] is a exergame developed by Haugland et al. for individuals with ID in mind. The game resembles the very famous game Pokemon-Go (see figure 2.8). The objective is to gather animals while roaming in a outside environment, this motivates the user into physical activity in the form of walking.

Figure 2.9: MovieCycle, mobile devices and exercise bicycles [12]

MovieCycle [12] combines mobile devices such as smartphones and tablet with a exercise bicycle through the use of sensors that measure the activity of the user. As long as the user continues pedaling on the exercise bicycle the tablet or smartphone will show entertainment, either in the form of a pre-recorded biking trail (see figure 2.9) or youtube material.

Most of the applications tested in the review were either marketed for kids or adults with different approaches towards both design, complexity, and goals. The information gathered in the review was mainly UI design, how exercised were performed or displayed in the application, the target consumers, how it helped with PA, and if it had Avatars [15].
Results show an abundance of exercise applications on the market for mobile devices like phones and tablets. Sadly, very few of these applications are suitable or accessible for people with ID; this could be due to the fact that research within app-designing and ID is still largely uncharted, with few definitive solutions and answers.

2.6 Designing Mobile applications for people with ID

When designing any IS, the success and adaptation are heavily reliant on the design and ease of use. Because of this the international organization for standarization (IOS) has created the Ergonomics of human-system interaction [32]. While this defines clear guidelines for human-centered design for interactive systems, including people with disabilities in this framework has proved

difficult.
This is due to the very nature of intellectual disabilities, often making designs and functionality too complex or difficult to use. As of yet, there is no standardized method for developing information and communications technology (ICT) for people with ID; however, when designing a user interface, there are two important concepts:

- **Accessibility**: A set of specific functional elements that makes it possible for people to use the application.
- **Usability**: How the application works, and how people interact with it (effectiveness, efficiency and satisfaction).

Research on user interface design for people with ID on mobile applications have made a list of recommendations any developer should take into consideration [33, 34, 35]. These are grouped as follows:

- **Navigation and graphic design**:
  - The mobile device must have a consistent and simple menu.
  - Buttons should include images or symbols to signify their purpose.
  - Warnings and feedback should stay on the screen until user respond.
  - The device shall notify the user with sounds, vibrations or icons.
  - User input should be minimal.
  - Simple gestures.
  - User interface should be simple and consistent.
  - Error identification and preventing mechanism in apps.
  - User input should be guided by labels and instructions.
  - Size of "clickable" elements should be increased.
  - High contrast between text and background.

- **Requirements to text**:
  - Reduce cognitive load by use of related images.
  - Language should be in easy, breif and concise form.
  - Provide text alternatives for non-text content.
  - Titles should be short and simple.

- **Personalization**:
  - Adaptable menu that can be adjusted to different needs.
  - Number of functions should be limited to avoid cognitive overload.

2.7 Mobile Assistive Technology

An increase in the use of mobile assistive technology (AT) for people with ID has been celebrated as the most substantial benefactor to the rehabilitation of people with ID. AT designed to remove as many of the boundaries that might be considered a hindrance to people with impairments.
Several studies indicate that by implementing AT for people with ID has a positive effect and can alleviate difficulties [36] such as impaired memory or ADD

Use of AT has proven to have the following advantages for people with ID [37]:

- Lasting benefits: Some cases show good results in memory exercise, even when the devices were taken away.
- The portability and size of mobile and tablet devices are the appropriate size for everyday use.
- In everyday use, people with ID prefer the use of electronic devices. They are considered more effective than traditional methods, and the user finds them more entertaining and comfortable.
- The use of electronic devices give the user more independence and make them feel included and involved in current trends.

2.8 Development platforms

For the development of the AGA application, the Unity[38] framework was found to be the most suitable for the project for some very specific reasons; Unity has a long track record on the market with a large active community supporting it. In addition, it allows for deployment in both iOS and Android.
The current AGA application is developed for Android for two reasons; iOS has a rigorous set of rules [39] before any app is launched in their store, while Android is much more lenient in this matter. Second, Android is more affordable and has a larger userbase worldwide.

2.8.1 Unity

Unity is a cross-platform game engine designed by Unity Technologies in 2005 [38]. The Unity framework consists of multiple layers(Scenes, Canvases, etc.)

and tools to help navigate and construct a game either in 2D or in 3D. Introducing a real-time 3d representation of the game environment while also giving the opportunity to manipulate objects and behavior makes for a strong tool. The programming or "scripting," as it is referred to in Unity, is done in C#. Scripts are attached to scenes, canvases, or literal objects in the game in order to generate any desired behavior.

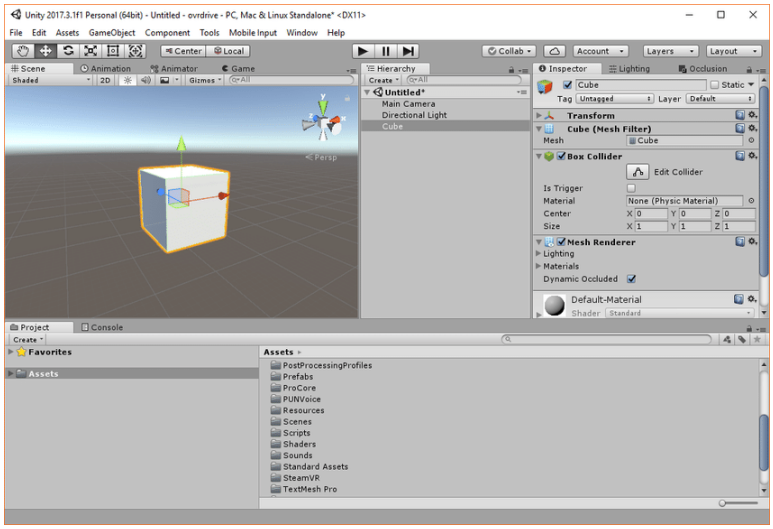

Figure 2.10: The Unity environment.

2.8.2 Visual Studio 2017

Visual Studio is the selected integrated development environment (IDE) for Unity [38]; whenever editing or programming is required, Unity will automatically guide the user to Visual Studio, this is because of its integration with the unity framework and associated libraries.

2.9 mSpider

In order to collect data from participants in the AGA application, it was necessary to establish a connection to a suitable backend server.
The research project "mSpider – Motivation continuous Sharing of Physical activity using non-Intrusive Data Extraction methods Retrospectively" will be hosting and gather all application-related health data [40].
This project is run by Research scholar Andre Henriksen (UIT) and supervised by Professor Gunnar Hartvigsen (UIT).

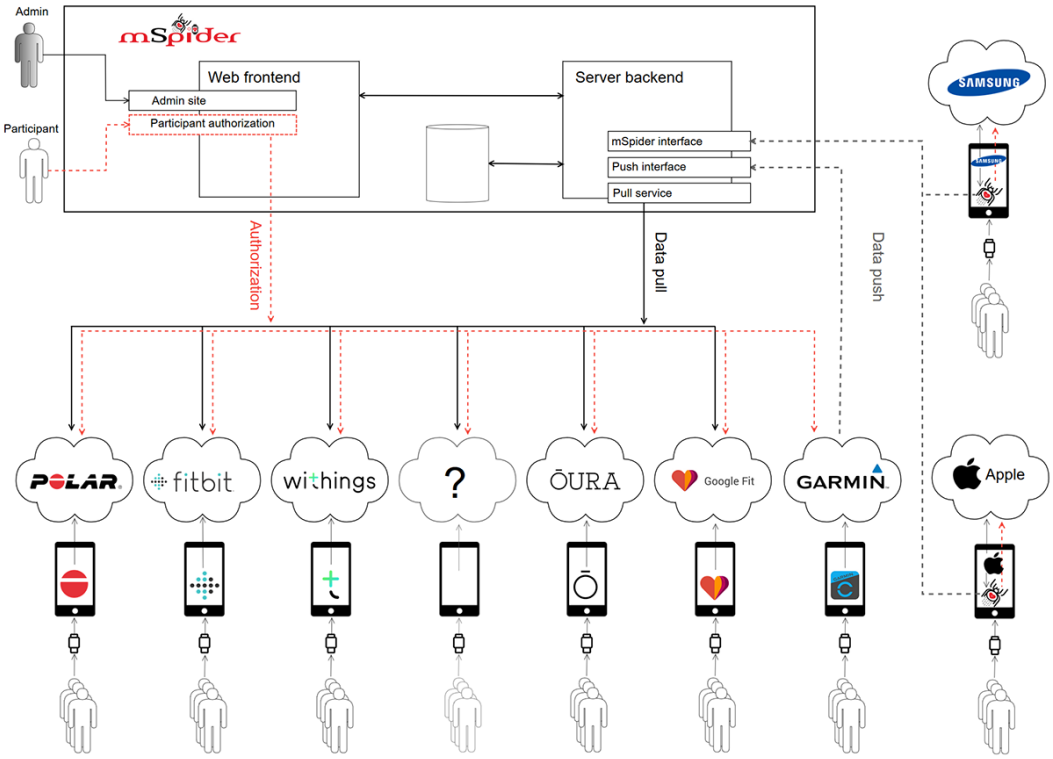

Figure 2.11: Overview of mSpider structure. Reprint w/permission [40]

The mspider-solution is a system for collecting different types of activity data automatically and continuously from different projects. The system is currently divided into three sub-systems;

- **A front-end web-portal ("mSpider web")**
  - Create, read, edit and delete studies.
  - Invite or remove participants for study.
  - Invite by mail or send reminders.
  - Download collected user data.

- **A back-end server("mSpider server").**
  - Collect data from study participants.

- **A mobile application("mSpider app").**
  - Collects from participants that do not have an API.
  - Samsung mobile device: data collecion through Anddroid SDK's.
  - Apple watch: Collect data through Apple Health SDK.

3 Method

In any field of science, there has to be a discipline, meaning that the research is regulated to be in accordance with a particular system of governance. In computer science, computing as a discipline [41] is an intellectual framework and basis for computing as a curriculum.

3.1 Paradigms for the discipline

There are three main paradigms regarding how we approach the work and define the discipline of computing.

Theory is the first paradigm and is deeply rooted in mathematics, it consists of four steps.

- Characterize objects of Study (**definition**);
- Hypothesize possible relationships among them(**theorem**);
- Determine whether the relationships are true(**proof**);
- Interpet **results**.

Abstraction is the second paradigm and relates to the experimental scientific methods, it consists of four stages.

- Form a **hypothesis**;
- Construct a model and make a **prediction**;
- Design an experiment, collect the **data**;
- Analyze **results**.

The third paradigm, **Design** is rooted in engineering, includes four steps followed when constructing a system(or device) to solve a specific problem.

- State **requirements**;
- State **specifications**;
- Design and implement the **system**;
- Test the **system**.

It is worth noting that since the discipline was created, much has changed in the development cycle of systems. This is especially true when developing for people with disabilities, often requiring re-worked solutions and unique designs—effectively turning the discipline into a looped activity were changed, and improvements are made.

3.2 Data collection

3.2.1 Literature review

Being the second installment of this project a systematic review had already been conducted in the summer of 2019 on exergames for people with ID, as mentioned in section 2.3.
A second, systematic review was also conducted for the last two years(2018-2021) since the project's first installment.
This resulted in a total of seven articles, which is not surprising considering the initial review concluded with only thirteen over a much wider time span.

With the material gathered in this installment and the previous there is a solid foundation to continue the development of the AGA application. The literature collected ranges from design solutions to effects of gamification and exergames. In addition, feedback from family, caretakers or others that have developed

applications like these is invaluable.

Shortly after starting the project, it became apparent that very few of the applications tested, actually contained the desired elements planned for the AGA application.
From the thirteen candidates selected by Wiik [15] only two applications was directed at PA for people with ID, these were FTU [31] and FunDoRoo [30].
The second systematic review revealed two additional candidates, CorpOperation [28] and MovieCycle [12].

From the collected data, the main points of interest were:

- **What Exergame applications existed for people with ID, and what they were trying to accomplish.**
- **Exergames show potential as a motivator for people with ID in getting the recommended PA.**
- **The accessibility for people with ID within Exergames is almost absent.**

3.2.2 Consulting within the Field

The project PA-ID and its sub-projects are guided by a large group of individuals that contribute with their knowledge within the field of psychology, assistive technology, user-centered design and intellectual disabilities, just to name a few.
Every week a supervision meeting was conducted online in Teams; anyone with interest or connection to the project could join in, give feedback on the topic at hand, and vice versa. With the diverse and extensive knowledge within the project group, ranging from psychology, behavioral studies, and intellectual disabilities, the amount of guidance and relevant material and literature was readily available. Throughout the entire duration of this project and thesis, Supervisor and Professor Gunnar Hartvigsen (UIT) has been the go-to for anything, either it was general guidence or advice on how to approach a problem and solve it.

The Co-supervisors, Professors Audny Anke (chief physician, UIT/UNN), Susanna Pelagatti (UNIPI) and Letizia Jaccheri (NTNU) was a great source of information and insight on all matters relating to ID and thesis literature.

Dr. Professor Santiago Martinez (UIA) provided literature regarding gamification towards people with ID while providing information about usability, such

as the system usability scale.

Additionally, since the project might include back-end storage in mSpider [40], research scholar Andre Henriksen (UIT) and Erlend Johannessen (UIT) are the people in charge of this aspect.

3.3 Evaluation method

3.3.1 System usability

In order to determine the usability of the application, a questionnaire was created using the system usability scale (SUS) invented by John Brooke [42]. This is considered a quick and reliable tool for measuring usability. By introducing ten questions where each question has five responses ranging from "Strongly Agree" to "Strongly Disagree," we can give the application a usability score. Odd-numbered questions are positive in tone; "I would like to use this application often" while the even-numbered questions are negative; "I found the system unnecessarily complicated". The questionnaire can be found in the appendix section.

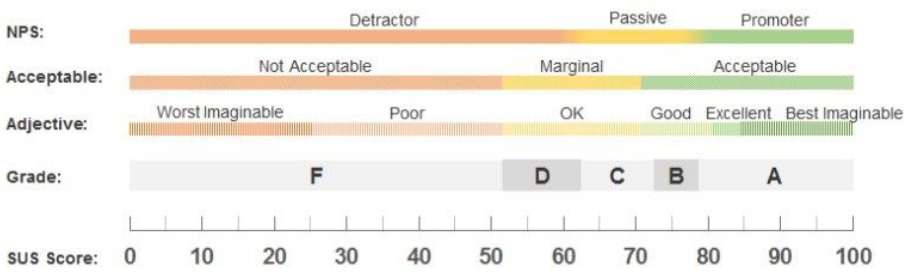

Figure 3.1: Grading on the SUS-scale.

3.3.2 Input during development

The weekly supervision meetings made it possible to have a continuous dialog regarding solutions and design choices made. The progress was broadcast live in each meeting possible to get the best feedback from all the participants. In addition to guidance and expert advice from the group, input on the complexity within the application and the graphical user interface (UI) were key points of interest.

3.4 Critique of methods

Due to the COVID-19 pandemic and national lockdown-restrictions constantly changing, it was impossible to do frequent real-world testing. Instead, the development process was guided by weekly supervision meetings in addition to a showcase and introduction at Kvaløya VGS. Here the application and its features were explained and demonstrated to special educators as an alternative to the intended real-world testing. The literature review only contains material from the period 2018-2021, this could be considered worthy of critique as the amount of material reviewed is significantly less. This was done as an continuation of the first review conducted in 2018, findings from both reviews have been considered during this thesis.

4

Requirements Specification

In this chapter, the functional and non-functional requirement specifications are established, followed by a summary describing them. In order to establish the requirement specifications for this project, the volere requirements specification (VRS) method was applied.

4.1 Source of requirements

When examining the current state of the AGA application, it became apparent that some core functionality required for a game application was still missing. Core functionality like individual users and reward-systems were important in order to achieve the goals for the application and hence became an important section of the requirements.
On matters relating to ID, the weekly meetings were a great source of information, input, and feedback. During the duration of this thesis, these meetings formed the requirements stated below in section 4.3.1 and 4.3.2.

4.2 Scenarios

Scenarios is common technique used to illustrate a situation and bring a certain product to life in a relatable fashion. In the scenarios below, two different situations are illustrated to show where the AGA application might be a good substitute and option in real life.

Scenario 1
Jonas is fifteen years old and was born with Downs syndrome. He lives with his parents and brothers in Tromsø; on days with clear and sunny weather, Jonas enjoys playing football outside with his friends and climbing trees.
However, during the fall and winter seasons, Jonas is not very fond of the rainy and cold weather outside; therefore, he spends most of this time inside on his mobile phone and tablet. His parents understand his frustration with the weather and rather wanting to rather play on his devices.
In an effort to bring some physical activity back into Jonas's life during this time of year, they have gotten several apps for his tablet that promotes exercise. Jonas enjoys this solution as it incorporates PA with the ability to stay inside and not have to deal with the bad weather. Every week his parents keep motivating Jonas to participate in the PA on his tablet in order to maintain a certain amount of healthy activity.

Scenario 2
Oddvar attends a daycare center for people with ID, the daycare center has been trying to find a suitable way to include PA into the daily routine for all its users. By introducing the Exergame application AGA on mobile devices at the center, they have introduced a new and modern approach to motivating its users into daily PA. Both Oddvar and the other users think the application is very entertaining, as they are motivated by their personal progression or competitive rivalry among them. By the end of the year, every user can even get feedback on their progression and amount of PA.

4.3 Defining the requirements

The requirements were identified by thoroughly examining prior work, and the general state of the AGA application after the project's first installment. Weekly meetings provided a constant flow of input and feedback, valuable information and guidence on finding the best solutions possible. The meetings consisted of the members mentioned in section 1.2. The requirements below were gathered during weekly meetings or were considered missing core functionality in a game environment. They were then documented using the VRS template [43].

The specification template consists of several key points that together describe the requirements and the reason for its existence:

- **Requirement Number:** Unique identifier given to every requirement in order to trace and reference it during development.
- **Requirement Description:** The intent behind the requirement.
- **Rationale:** The reason for the requirement.
- **Source:** Source of the requirement.
- **Fit Criterion:** defined goals the requirement has to fulfill.
- **Priority:** How important is the requirement?
- **Dependencies:** What other requirements(if any) have to be implemented before this one?

4.3.1 Functional Requirements

The functional requirements are absolute, meaning they are needed for the application to achieve its intended purpose. In other words, what the application MUST do. Without these requirements there would be no reason for the applications existence [44].

In the table below, the rationales behind improvements and new functionality in AGA is presented.

#	Description	Rationale	Source	Fit-Criterion	Priority	Dependencies
1	The application should support multiple users.	Multiple users can share the same device, but have individual progression.	Author	Each user has its own settings and PA data.	4	5
2	The application should retain the customized Avatar functionality even with multiple accounts.	Each user keeps their personalized avatar.	Author	Each user has a personalized avatar connected to it.	4	1
3	The application should communicate with mSpider back-end.	Generate health data and track individual progression.	Expert advisers	Generate Research material.	2	1
4	The application should be persistant, keeping data stored when closed or restarted.	Core functionality in any game or progression based system	Author	Important feature to keep users returning on regular basis.	5	4
5	The application should display some form of scoreboard.	With multiple users score keeping and competitive-elements is a motivator.	Expert advisers	Users can see their progression in a tab/menu.	4	3,4
6	When a user gains rewards or unlocks this progression should be stored.	User can come gain rewards and unlocks through progression.	Author	On return all the users progression is there.	5	3

4.3.2 Non-Functional Requirements

A Non-functional requirement improve the quality of life in the application. Meaning what makes it attractive, engaging for the user, easy to use, and reliable. These requirements pertain more to how the end-user perceives the environment rather than altering the core functionality of the application [44]. In the below table, we highlight some of the non-functional requirements that have been adjusted or added to the project.

#	Description	Rationale	Source	Fit-Criterion	Priority	Dependencies
7	With introduction of user the complexity should not increase	The application should still adhere to the guidlines states for people with ID	Expert advisors	Creating a user or selecting one should not be demanding.	5	1
8	Visuals and audio should be informative but not a disturbance	Visual and audio feedback has a positive effect on motivation	Expert advisors	The application should be guiding in both visual and audiable form, but not a source of cognitive overload	4	
9	New functionality should include the same assistive technologies previously implemented(text-to-speech, help menu, visual guidance)	Any new functionality should adhere to the guidelines for people with ID.	Expert advisors	The design should be consistent.	5	
10	New menus and functionality should be visually designed in the same manner as earlier	By keeping to one consistent visual design it creates familiarty for the user	Expert advisors	The user should not be confused by different visual design and layouts that might cause confusion	4	
11	Introduction of a animal companion or animal park reward-system should be present	Implementing motivational mechanics is a important part of gamification	Experts advisors	Users should be rewarded for participating in PA.	4	

5

Design and implementation

5.1 Design

Design is the third paradigm in computing as a discipline and consists of four separate steps. In this chapter, the system's design and implementation are discussed in a broader manner to give a comprehensive insight into the improvements and additions made. Since the applications will be used by people with ID it is imperative that all additions and improvements made adhere to the accessibility and usability designs [45].

5.1.1 Initial UI-design for AGA

In figure 5.1 below the initial UI layout of the AGA application is shown in a flow-chart. Here the user starts the AGA application direcly in the user customization panel rather then at the added welcome panel shown in figure 5.2.

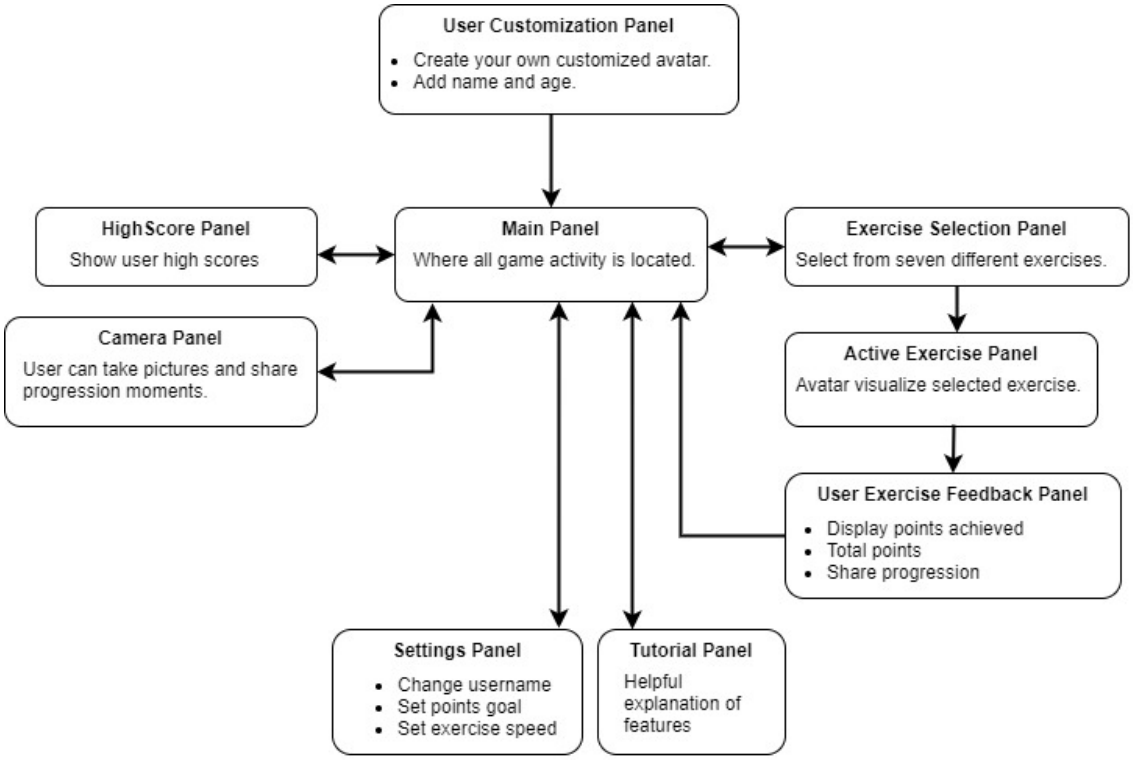

Figure 5.1: Initial UI diagram of the AGA application.

5.1.2 Final UI-design for AGA

In figure 5.2, the current UI layout of the AGA application is shown in a flow-chart. The colors white, yellow and green indicate if it is a new addition, changed or unchanged from its previous version.

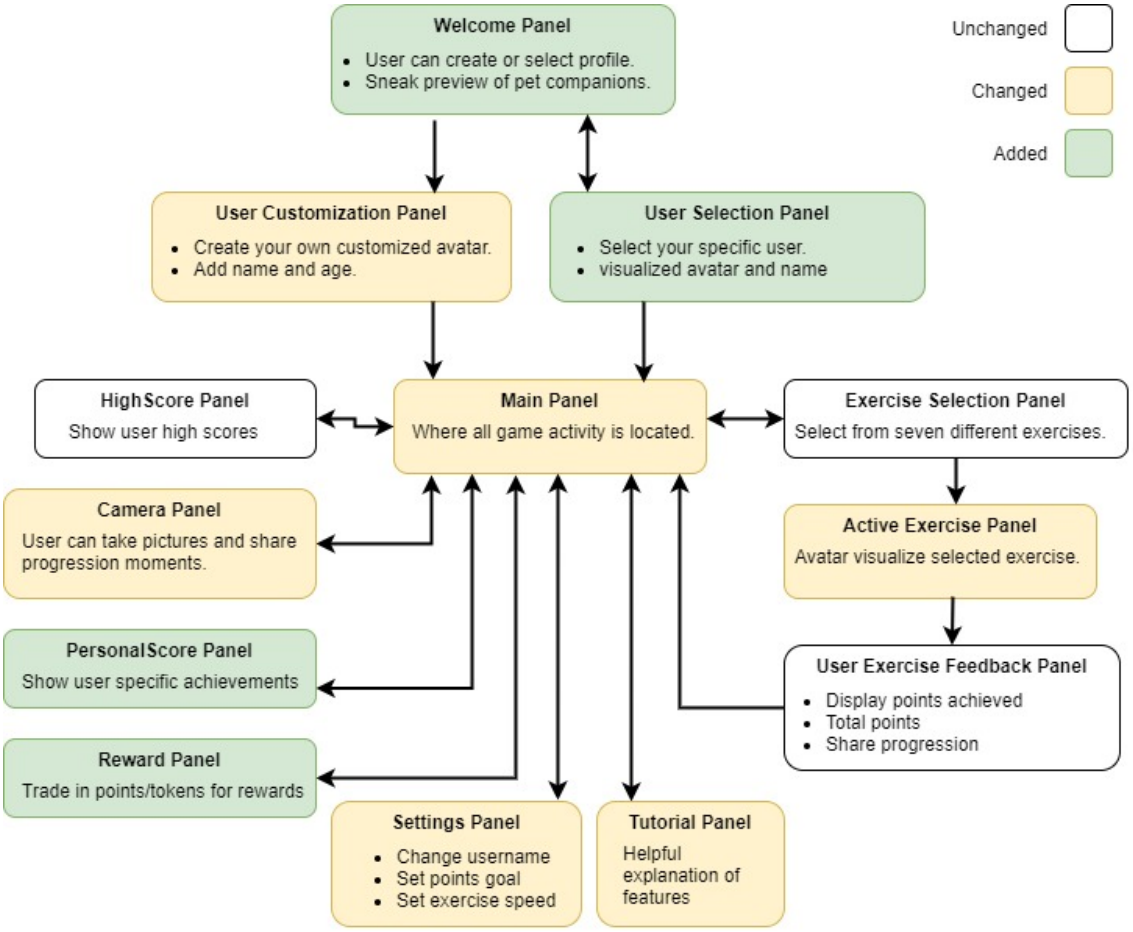

Figure 5.2: Final UI diagram of the AGA application.

5.1.3 Base design

Some of the base design was already implemented in the AGA application prior to this thesis. By Base design, we are primarily talking about buttons and interactions that make up the application's core functionality, which means how the user traverses menus and options throughout the application.
This could be how the user starts the game, navigates once in it, and various options menu's that might exist in the application environment. While AGA

did not have a game "front" or "starting screen" until now, it had defined an in-game base design.
The starting menu UI added in this iteration has derived its functionality and look from the in-game environment, while the additions in the in-game environment have been modeled on the previous work in order to keep a familiar and coherent UI.

Figure 5.3: Base design elements

Figure 5.4: Familiar design layout

Figure 5.5: consistent elements

In figure 5.3 above, the base design for the in-game environment is outlined in red. The new and added feature "personal tab" can be seen in the bottom-right corner, adhering to the initial base design.
In figure 5.4 and 5.5, elements marked in red such as buttons, layouts and symbols, are consistently kept the same design to minimize miss-interpretation or confusion while at the same time making it familiar in use.

5.1.4 Welcome / Start panel

On application start, the user is greeted with a friendly and inviting welcome panel. A premade 3d-avatar is displayed together with his animal companions as a way of showing the user some of the possible rewards ahead when using the application.
In figure 5.6 The button layout is kept very simple, only allowing for either user creation or user selection. The user creation button is by design made smaller as this option is often only chosen once by individuals using the application. The play (Spill) button is for selecting an already created user. With input from the weekly meetings, the solution was refined over time, as shown in figure 5.7. Comparing the two, the final design has a much more inviting environment and guiding structure, illustrating how feedback can improve on design choices.

Figure 5.6: Final design

Figure 5.7: Starting design

5.1.5 Multiple users

The introduction of multiple user profiles within the application has two very important benefits, being both a game and research project intended for real-life health-data collection.

Firstly, having separate users allows for individual progression within the application. Meaning that all exercise done, points achieved, rewards collect, and personal avatar is connected to that specific user. The user no longer shares a single progression within the game resulting in a user who feels more in control and personally invested in the application and its features.

Second, being able to differentiate the users of the application results in separate datasets. This approach is significantly better than just collecting "anonymous" single-session exercise data that cannot be connected with any specific user. Instead, each user's data is separated both in profile and health-data giving more nuanced information that can represent individual progression and physical activity for each user. A illutration of this system is shown in figure 5.8 below.

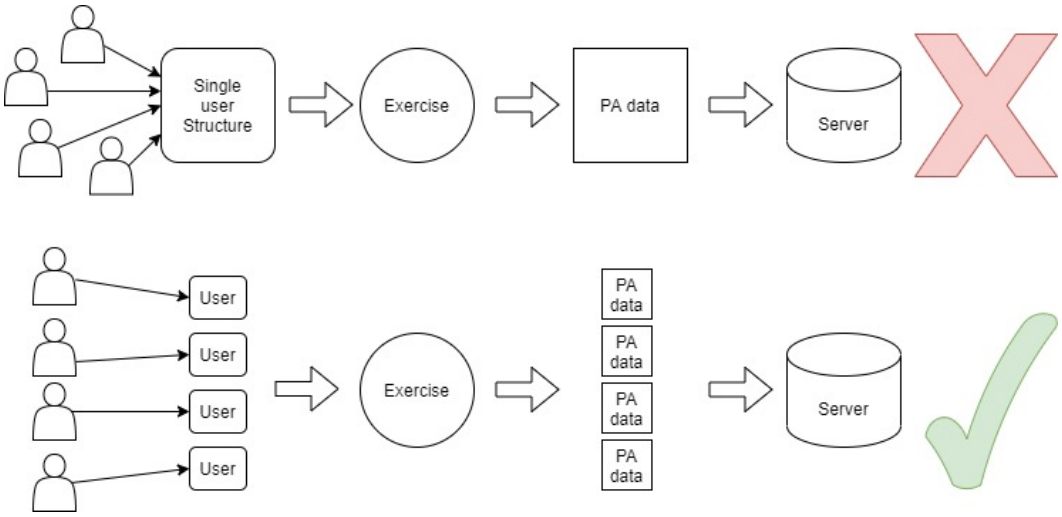

Figure 5.8: illustration of the benefits of multiple users

5.1.6 User Selection

Introducing a feature such a user account selection could be perceived as an added level of complexity within the application, which would become a barrier for the intended end-user.
Because of this aspect, the design is specifically made with the user in mind.
The actual selection of user account had to be as simple as possible, requiring minimal input from the user. In order to achieve this, the traditional approach with passwords and usernames was not a good solution as they may be lost, forgotten or entered incorrectly.
Instead, the user is greeted with a neatly designed character selection panel that represents all the different users by displaying their individual Avatars created with the account. The figures 5.9,5.10,5.11 and 5.12 all show different users on the selection panel.

Figure 5.9: Showing female user on the selection panel.

Figure 5.10: Showing male user on the selection panel.

Figure 5.11: Many combinations to choose from.

Figure 5.12: Great diversity in avatars.

5.1.7 User Login

With the possibility of multiple users on a single device, the question of user login was heavily discussed in order to find the best possible solution for an application of this nature.
The final solution is a simplified version of a generic user login, where on creation of the user, a unique key is added to the profile. This eliminates the need for demanding input, such as passphrases or passwords, while at the same time uniquely separate the users. Read more in the future work session about possible solutions and additions to the current implementation.

5.1.8 Star progression system

Changes were made to how progression is done with star rewards; initially, the system would only allow for the collection of three stars every day. The idea behind this restriction was that users would have to come back every day

to collect new stars, but it gave no indicators about this aspect while playing the game. Instead, the user is now able to collect as many stars as they chose. Together with the introduction of animal companions, this change made for an added layer of motivation aspects to the game as shown in figure 5.13 below.

Figure 5.13: A more circular design.

5.1.9 Animal companion reward system

The animal companion was an excellent idea featured in the future work segment of Wiik's thesis [15]. The animal companion reward system is designed with participation and motivational mechanics in mind. As the user participates and completes a certain number of exercises, they are rewarded with their own in-game avatar pet companion animal as shown in figure 5.14 and 5.15.

Figure 5.14: Sneak peak at rewards in welcome panel

Figure 5.15: Unlocked pet companions appear on main panel

By implementing this system together with the already present star-system, the user is rewarded for returning and participating in personal progression. The animal companion is a multi-level reward system designed to motivate the user to return and participate in exercises regularly.
If the user participates in exercise and over time collects enough points, they are rewarded with an animal companion. The companion is shown on the application's main menu.
This system can easily be altered to require more points or participation over time as a factor. Because of this, the reward system looks at more extended periods of participation. If the user has already unlocked its first animal companion and continues with regular exercises, they can unlock even more animal companions. Combining time and exercise with rewards becomes a big incentive for the user to return and hopefully establish their own exercise routine.

5.1.10 Personal Progression

Initially, the AGA application had a leaderboard tab where the user could see where they matched up against other users. The personal score panel is more focused on the individual user's progression. The information is presented in a structured and understandable manner, avoiding complicated metrics or values that are not necessary. As shown in figure 5.16, the user name is displayed to give a clear indication that this is the actual user's account and information. Next is the total number of points earned and how many exercises it took to achieve. If the user has been rewarded either stars or animal companions, this is also displayed. On the bottom, a green button leads to the reward panel shown in figure 5.17. The reward panel is a work in progress, but the intention is to make the reward system more engaging and dynamic in the future by letting the user make their own choices in regards to rewards.

Figure 5.16: Watch and keep track of your personal progression.

Figure 5.17: Reward Panel, future feature.

5.1.11 User progression

Initially the user progression in the AGA application was aimed towards unlocking stars based on the number of points rewarded by doing any of the possible exercises included (six in total).
With the addition of pet companions as a reward, the user now has multiple goals they can work towards while exercising. During the system's test period, it was configured so that for every tree golden stars, the user was rewarded with a pet companion that will appear on their main panel.

5.1.12 Data Storage

Initially, the AGA application stored no data about its state or users. This meant that every time the application was started, it had no information about its state and was a clean slate. With the new additions, such as multiple users, the need for persistence within the application was imperative. In order to handle the different users and states within the application, storage had to be done in two separate structures.

Application specific

In order for the application to keep track of all its different users, a single variable is stored on user creation and referenced on each new user creation. Additionally, a list of unique keys is stored in a list and handed out on each user creation.

User profile specific

All data related to the user is stored locally on the device, with plans of storage in mSpider in the future. This data includes the following:

- Username.
- Unique key.
- Total points rewarded.
- Pet companions rewarded.
- Avatar related data (girl/boy, hair, shirt, pants, shoes, etc).
- Total stars rewarded.

5.1.13 Data collection

While health-data collection was of high priority, the application was considered too early a prototype to generate good and nuanced data. Instead, the focus was on implementing the mechanics and functionality that generate this data. This data has been structured into two separate parts, the user profiles, and their exercise sessions. With information on each individual exercise done, it can establish information about the user's exercise patterns. In the future, this information could be compared to activity recorded in wearables like Smartwatches and Fitbits.

5.1.14 Exercise sessions

For each exercise session, a data structure containing is generated. This structure holds the following elements, which are only related to the exercise in question.

- Username.
- Unique key.
- Total points rewarded this session.
- Date and time for start of exercise.
- Date and time for end of exercise.

5.2 Implementation

Throughout the thesis, several functionalities have been added or improved in order to make the new design work in an intuitive and functional manner. Below we go further into how these improvements have been constructed and implemented into the already established environment of the AGA application.

5.2.1 Unity hierarchy

At the beginning of the thesis, the initial plan was to divide the application into multiple "unity scenes", as intended when working with the framework. By dividing the application into smaller segments, we are able to reduce the overhead generated by all game objects and functionality.
Only assets connected to the specific scene are loaded, giving better performance on mobile devices and a more modular approach to the structure as a whole.

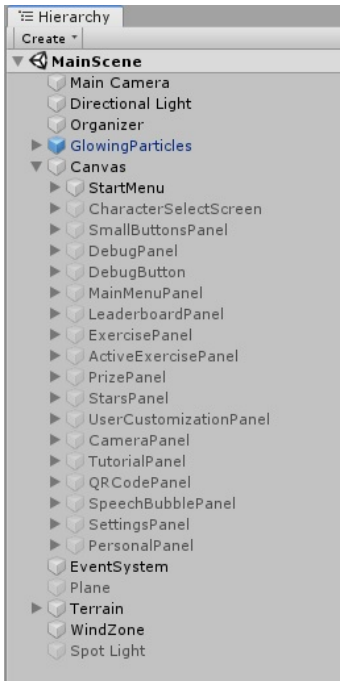

Figure 5.18: Unity Hierarchy: Mainscene with all canvases.

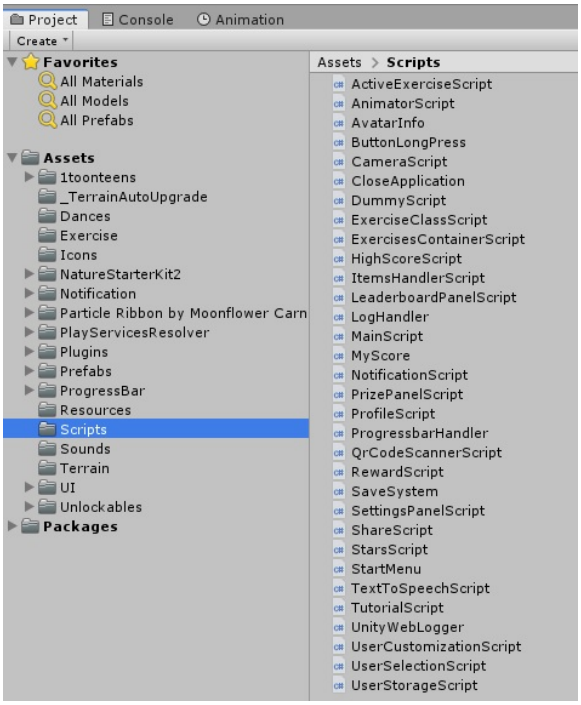

Figure 5.19: Unity Assets: Scripts connected to canvases.

It soon became apparent that the application had reached a point in development where both functionality and dependencies made it too demanding to split into different scenes without remodeling the entire application. As shown in the figure 5.18 where all canvases are contained under one scene, the "MainScene". The result is a hybrid solution, where some elements are made less dependent than earlier but still remain in a single unity scene.

5.2.2 Script structure

Below in figure 5.20 the entire structure of the AGA application is illustrated. The only element missing from the diagram is the dependency of the scripts. However, adding it would become too complex and cluttered. The white boxes represent the UI-panel's while the green diamonds are the scripts connected to them.

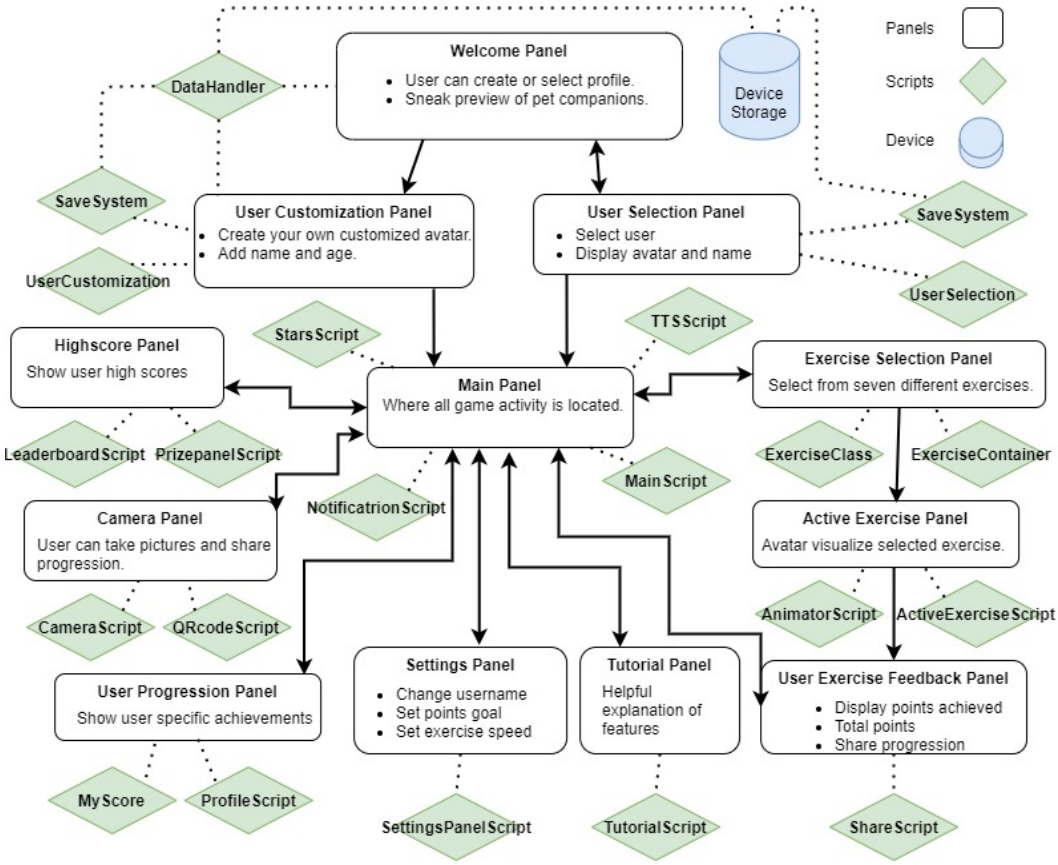

Figure 5.20: Scenes with respective attached scripts

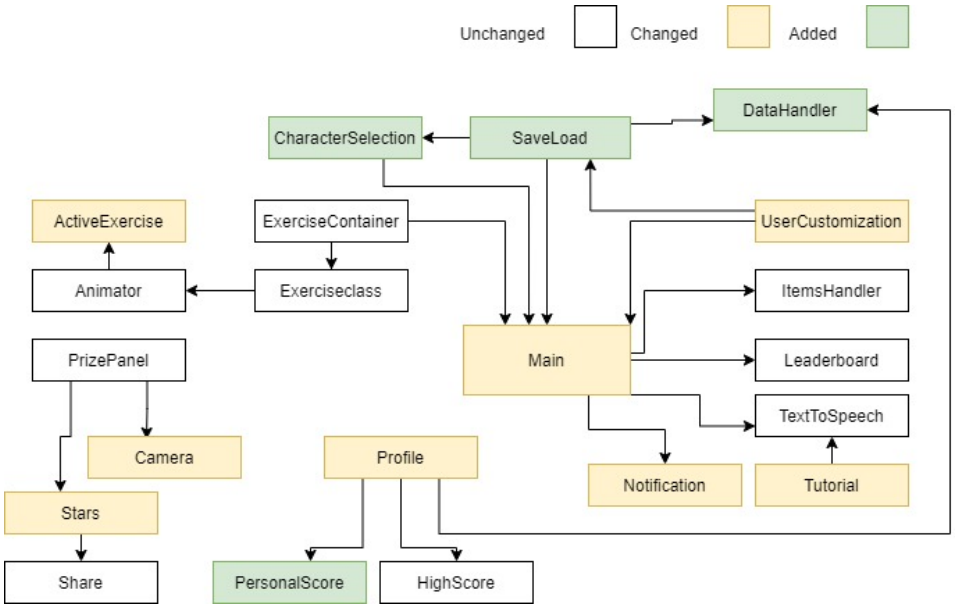

Figure 5.21: Dependency of scripts.

Above in figure 5.21 all scripts within the application is illustrated, the dependency between them has been made as easy to understand as possible. The major additions and changes include the character selection script, save and load functionality for data and the profile script. Other elements have minor changes to functional elements, such as adding of notifications, manipulation of player data and connecting star and animal reward progression.

5.2.3 User creation and selection

User creation and selection are closely connected as a user has to be created in the user customization panel before it can be selected in the selection panel. When generating a new user with its own Avatar the information is stored locally on the device once the customization is completed. The user is then navigated to the main panel. Upon revisiting the application, the user selection can now be selected and should contain a list with all users ever generated on the specific device as illustrated in figure 5.22.

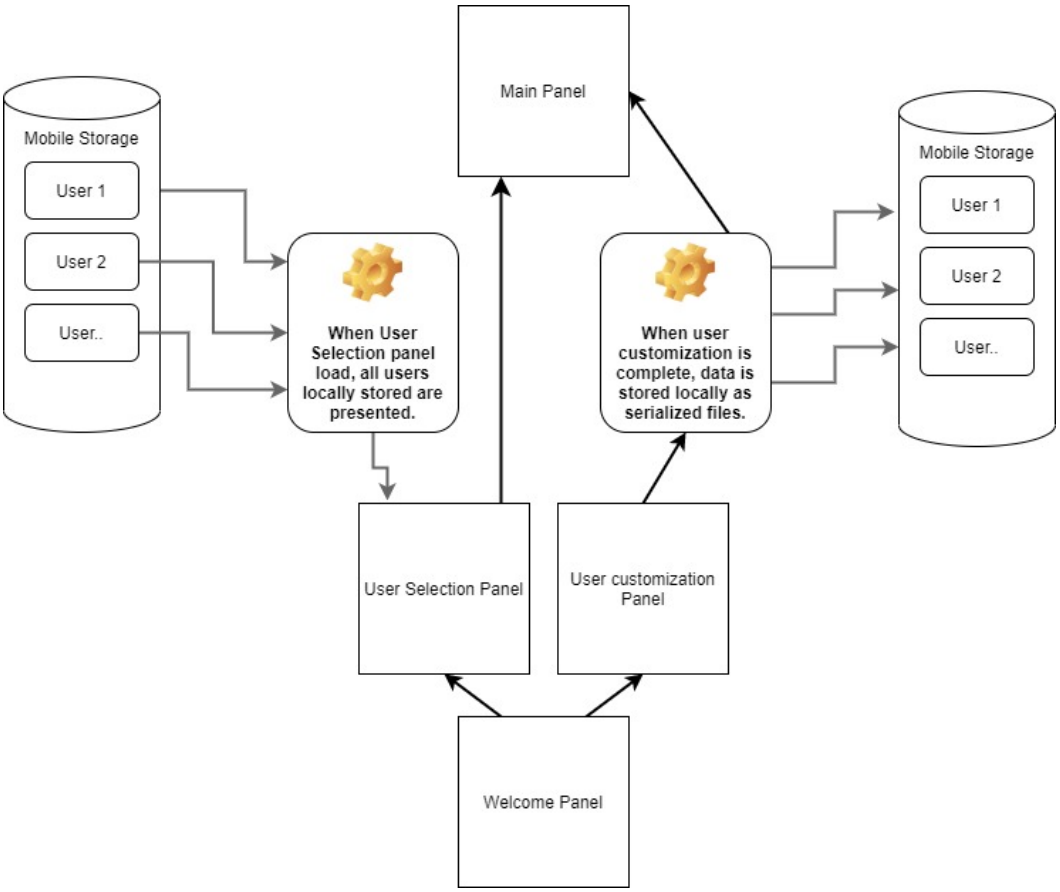

Figure 5.22: Flow-chart of user profiles

5.2.4 User profiles

With the added features and multiple changes made to the application, it was necessary to extend the initial userinfo struct connected to each profile, see figure 5.23. The reworked reward system, now containing the additional animal companions element and the introduction of a personal score panel, required more information gathering on the user. For the application to display any information of interest, values such as TotalPoints and TotalExercises are added. These are required in order to give nuanced health-data about the user's activity. By tracking the user's activity over time, there are two positives; the user gets constant feedback on progression, while the application collects useful health-data. The Companion value is stored in order to keep track of the user's unlocked pet rewards.
The last values ChosenHair, ChosenShirt, ChosenLeg, ChosenShoe, and IsBoy, are all needed to recreate the user's avatar in the user selection panel.

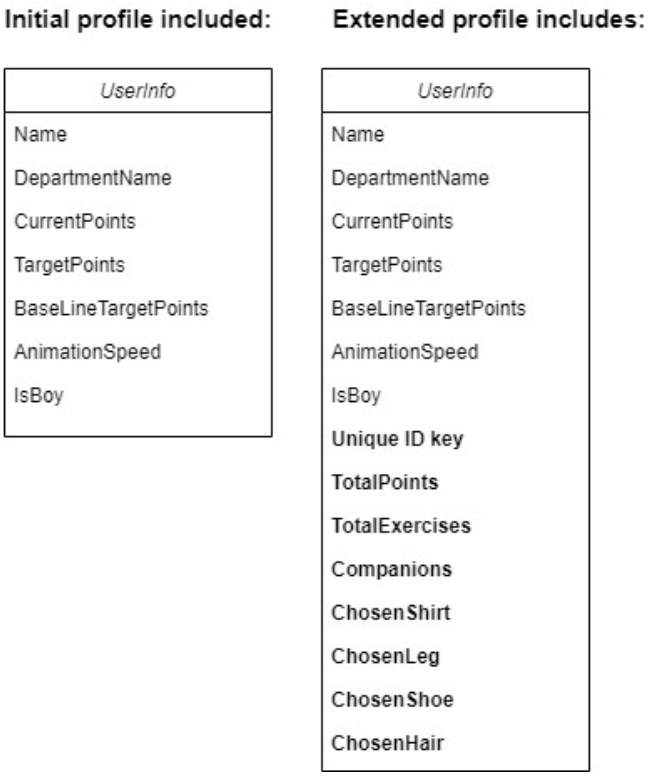

Figure 5.23: UserInfo struct has been extended to hold more information

5.2.5 Progression system

User progression is now measured in two aspects:

- Unlocking golden stars through point accumulation.
- Unlocking Animal companions through golden stars accumulation.

By participating in different exercises, points are accumulated. When a given number of points are gained, a star is rewarded.
The second aspect is the pet companion, which is rewarded when a certain number of golden stars have been accumulated.
Stars are represented at the top of the screen, as tree grey stars. As the user is rewarded with stars, a window will pop up and congratulate the user on its latest achievements.

A short animation will also show each star turning golden upon achievement. When pet companions are rewarded, a pop-up window will congratulate the user on its latest unlock and automatically display the pet on the main panel. The system is designed in such a fashion that if needed or feedback dictates it, the number of exercise can easily be modified to a more suitable amount for the user.

5.2.6 Notifications

With new rewards and functionality, it was necessary to update the notification system to accommodate these. Additional notifications have been made for each animal companion unlocked together with TTS as shown in figures 5.24 and 5.25.

Figure 5.24: Initial notification on ended exercise.

Figure 5.25: Notification for animal companion reward.

5.2.7 Persistent progression and storing

By introducing local device storage for both game-state and individual users, the application is now persistent. The result is that users may now exit the application and continue their exercise later without the fear of losing their progression.
All game-state and user-specific data are serialized into unity-specific files that cannot be opened or read in plain text. This is in order to add an additional layer of security where possible as shown in figure 5.26. While this is not a feature the user directly interacts with within the application, the functionality brings a huge positive aspect to the application and its users.

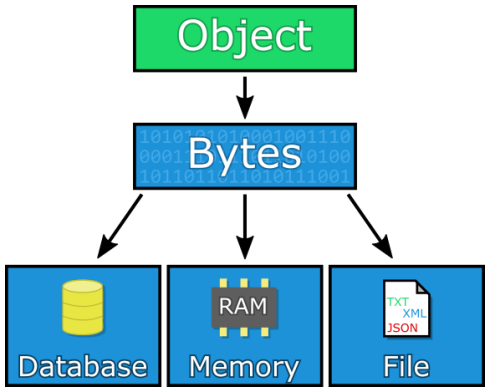

Figure 5.26: Visualization of file serialization.

5.2.8 Star reward

The star system was slightly reworked during this installment, allowing for all three stars to be collected as many times as the user would like to.
In the initial system, only tree stars could be collected every 24 or 48 hours. This was considered less motivating and easily misconstrued as a faulty system not reacting to progression. No information about this restriction was given to the user either.
In addition to the rewarded stars shown at the top of the screen, an additional counter has been placed in the personal score panel. Here the total number of stars rewarded is displayed (shown in figure 5.17), as the starts on the top of the screen will only track tree at the time.

5.2.9 Animal companion

As shown above, in figure 5.23, the userinfo struct now contains information about points, stars, and companions. Points define how many stars are rewarded, and stars define how many companions are rewarded. In the current system setup, the user is rewarded a chicken upon collecting the first three stars (see figure 5.27). If the user continues to exercise and manages to reach six stars, the reward is a cat (see figure 5.28). As the user returns to the main panel, a simple check is done in the user profile to determine if a chicken or cat should be shown on the screen.

Figure 5.27: First companion : Chicken.

Figure 5.28: Second companion : Cat

5.2.10 User health data

The health-data submitted by each user is as mentioned earlier a struct for each individual exercise. The struct only contains the needed information to make the data valid for future research.
The struct contains the user accounts name, unique key, exercise and parameters regarding time and points (see figure 5.29).

Figure 5.29: Data collected during exercise.

6

Testing and results

From the very beginning of the project, weekly meetings were conducted on Teams [46] discussing the direction of the project. With the guidance of project members in the PA-ID group (see section 1.2) it was possible to have a continuous flow of ideas and feedback throughout the development process. Due to the COVID-19 pandemic, this was vital as real-world testing was very restricted due to national regulations. The closest alternative to real-world testing was a meeting arranged by Professor Audny Anke at Kvaløya VGS in January. Teachers and supervisors who attended the meeting all work directly with youth with ID.

6.1 Testing procedure

The AGA application was initially tested in its first installment. Here the result showed good promise both on the SUS-test, motivational and engaging elements within the application. Feedback received became part of the foundation for this thesis in an effort to further improve on the functionality and vision set for the application.
The same approach to testing is used in this thesis by utilizing the system usability scale and general feedback from special educators, supervisors and experts within the field.

6.2 Introduction at Kvaløya VGS

Due to restrictions put in place because of COVID-19, a testing environment with multiple users over an extended period of time proved impossible.
As an alternative, a meeting was held at Kvaløya VGS with school supervisor Tove D. Aandstad , special educators Frank Caglar-Ryeng, and Ole Nerum Hatlen. Both Audny Anke and I attended the meeting, where an introduction of the application was shown on a big screen. The participants could ask questions, try the application and give feedback.
After the meeting, all participants were asked to fill out a SUS-questioner. Questions regarding new technology and mobile devices were of interest as they may help shed light on what is popular among the youth today. It may also uncover ideas and possibilities not yet considered in the project.

Figure 6.1: application running on Samsung Galaxy S9 and Tab A

The application was tested and shown on the following devices:

- *Huawei P10* - 2017 running android 9
- *Samsung Tab A* - 2019 running android 9 (figure 6.1)
- *Samsung Galaxy S9* - 2018 running android 9 (figure 6.1)

6.3 Feedback from introduction

After giving a presentation of the AGA application, an introduction into all features and potential "pathways" within the game was shown and explained. While the application was easy to use and had great potential, lecturers Frank Caglar-Ryeng and Ole Nerum Hatlen contributed with some excellent insight from their perspective that might further improve the user experience. Below is a condensed version of the elements discussed.

Figure 6.2: Example from other games with the reward system and tokens

From both Frank and Ole's experience, when working with numbers, it is helpful to keep it simple. Understanding the true value of a high number can be problematic.
The solution for this could be reworking the points into a token-like system with smaller amounts. These tokens could be a trading commodity for even more rewards (see figure 6.2), as these systems seem to have a positive and engaging effect in their opinion.

Figure 6.3: First draft in the AGA application.

In Figure 6.3 above, A first draft of the token-idea pitched by Frank and Ole is illustrated. This approach to rewards requires more interaction from the user, hence raising the level of engagement during exercise and progression.

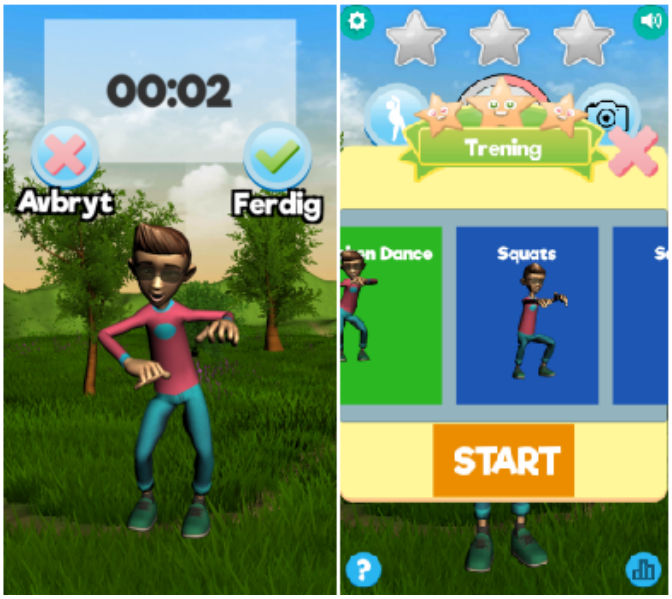

Figure 6.4: Current exercises are endless

Regarding the active exercise functionality, it was suggested by Frank that it might be more beneficial to have a timer counting down rather than up, becoming an endless session accumulating time (see figure 6.4). From an exercise perspective, this make good sense, as this is now much closer to interval training.

6.4 Questionnaire results

While COVID-19 restrictions made real-world testing problematic, some feedback was made possible from the meeting at Kvaløya VGS. Each of the participants was presented with a sus-questionnaire after a live presentation of the applications.
While the system usability scale is very simple and the dataset is small, it still gives insight into how the application is perceived by users.

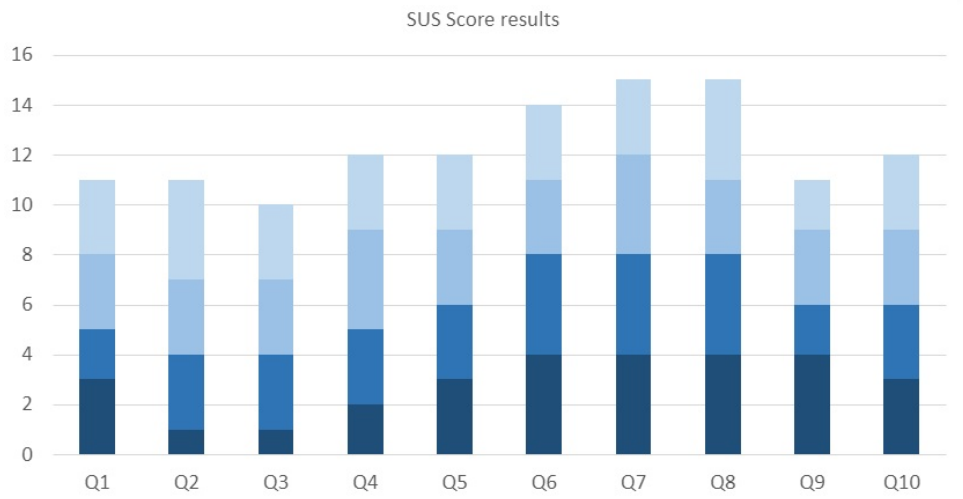

Figure 6.5: Questionnaire feedback among participants.

The results from the different participants are shown in figure 6.5 above. From the data collected, one deviated slightly with lower scores. The remaining participants had very consistent scores. This has more impact than under more ideal circumstances where the number of participants is higher. It would be ideal with twenty or more, but this was not possible during the pandemic.

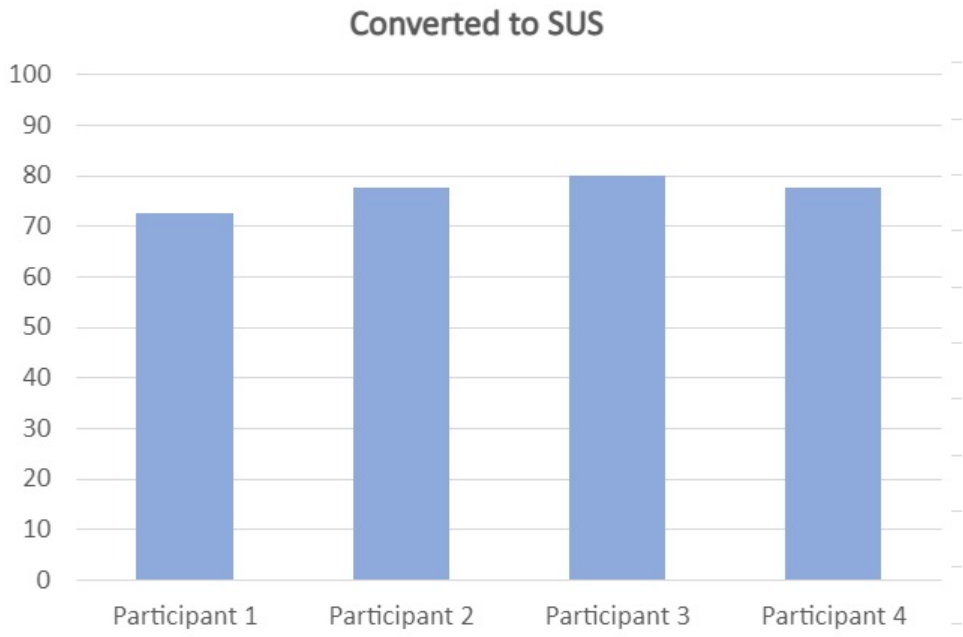

Figure 6.6: Converted SUS-score for each participant.

By reducing all odd-numbered question scores by one, and subtracting even-numbered question scores from five the convertion can be done. Scores from all participants are then added up and multiplied by 2.5 (see figure 6.6). After converting all the question scores to their respectable SUS-scores these are the following results. The application scored a healthy avarage of **76.875** which is well within the GOOD grade on the sus-scale [42].

- Participant one had the lowest score of **72.5**
- Participant two had **77.5**
- Participant tre had the highest score of **80**
- Participant four had **77.5**

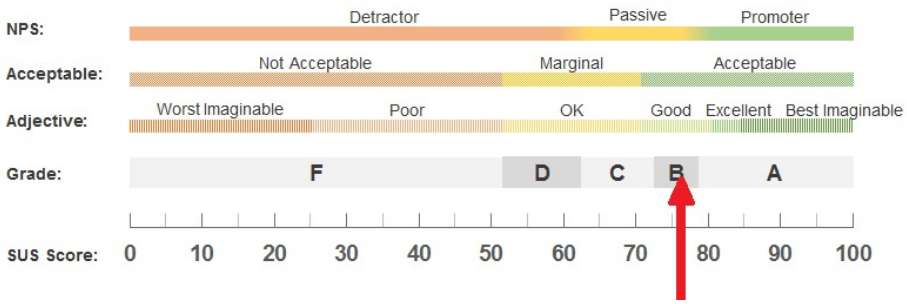

Figure 6.7: Where the application lands on the SUS-Scale.

As shown in figure 6.7 above, the application scores GOOD (B) on the system usability scale, but there is still room for improvement in future installments as the application might grow in both layout and design.

7

Discussion

7.1 Requirements

The following requirements were added to the project during this thesis period:

Functional requirements :

1. The application should support multiple users.
2. The application should retain the customized avatar functionality for each user.
3. The application should communicate with mSpider back-end server.
4. The application should be persistent, keeping data stored when closed.
5. The application should display some form of score board.
6. When a user gains rewards or unlocks, this progression should be stored.

Non-functional requirements :

7. The Multiple-users feature should not add complexity to the application.
8. New menus and functionality should adhere to the existing design layout.
9. Visuals and audio should be informative but not a disturbance
10. New functionality should include the same assistive technologies previously implemented (TTS, tutorial panel, visual guidance).
11. The application should include pet-companion (animal) reward system.

7.1.1 Requirement 1: Multiple users

The implementation of multiple users is considered one of the most essential functional requirements. Once the application can differentiate between users, it opens for a whole new world of possibilities within user-feedback and individual progression.
This helps make the application more appealing and engaging to the end-user as they feel more personally invested. No longer is progression shared on a single user with a single avatar. Users can now generate their own accounts with an accompanied customized avatar.

7.1.2 Requirement 2: Retaining customized avatars

With the introduction of multiple users, it was imperative that the application retained the user's customized avatar. In order to achieve this requirement, both the user customization and user profiles had to be improved and expanded to contain data on each avatar. As Unity is unable to serialize game objects of this type, an alternative solution was made. By storing the index choices during the creation of the user profile, then passing this information to the specific user's profile, it enables for recreation of the exact same object every time the user-profile is loaded.
The avatar object is comprised of body model (gender dependent), hair type, shoe type, shirt type, and pants type. If the models are expanded to include more clothing options, this can be achieved without significant changes.

7.1.3 Requirement 3: mSpider communication

This was one of the more ambitious requirements for this thesis, establishing a working connection with the back-end server mspider.
While this requirement is still not completed as a whole much of the groundwork needed to send the health-data in question is implemented. Both user-profiles and exercise sessions have been extended to contain broader and more informative data. Data can either be collected as a whole (user profile and exercise session) or individually. The data containing each exercise session has been extended slightly to include start and finish time, in addition to points earned (needed for the future development of the high score table).
Functionality has been added that stores the data on the device and prepares it for transmission back to mspider. This is required for instances where the device might not have a connection to the internet but instead has to hold on to it for a later time. There is yet to be done significant testing against the mspider back-end. As the application has to both authenticate, send and receive information in a proper manner. This will require some testing efforts, finding the most appropriate checkpoints within the application to do the affirmation actions so as not to disturb the user experience. Research scholars Andre Henriksen and Erlend Johannessen at mspider have already created a study group (collection of all users) for the application. On authentication, the application should receive a token, and a unique-id that is stored locally on the device before data collection and general configuration can be done.

7.1.4 Requirement 4: Application persistence

In order to introduce both multiple users and sustained progression, application persistence is necessary. First, the application is required to store some information about its current state. Keeping track of the number of users created and a list containing unique keys is required. This information is never intended for back-end services.
Second, generated users and their profiles are stored separately on the device in serialized unity files.
In the future, information about the individual user profiles could be stored exclusively in the cloud. A downside to this solution would be when the application does not have access to internet connectivity, effectively shutting the user out completely.

7.1.5 Requirement 5: Scoreboard feature

While the initial installment of AGA had a High score table, it was far from completed but retained much of the work needed when an eventual connection

to mspider had been established.
Since work with connecting to mspider is still not completed, and other necessary functionality was missing, it was considered essential to give the user a place they could get informative feedback on their exercise, rather than just a single value stating points achieved.
Feedback is achieved through the personal score panel; it is located on the bottom left of the screen, next to the main panel's high score button. In the personal score panel, the user can inspect their points earned and exercises completed together with the number of pets and stars unlocked so far. The personal panel is intended to be closely integrated with the reward panel intended for trade-in rewards.

7.1.6 Requirement 6: User progression persistence

As mentioned above, in order to achieve multiple users, the device has to store their individual user profile. When creating a user, the profile is stored on first game entry, after that the progression is stored after each exercise conducted. When the user participates in exercise or gains rewards the application will automatically save the progression. All user profiles are stored as serialized unity files on the device, which is very helpful in cases where the device may not be connected to the internet.

7.1.7 Requirement 7: Keeping complexity low

Much time was spent trying to keep the complexity low, and some compromises had to be made in order to introduce new features such as multiple users. After much discussion with both the supervisors and experts within the field of ID, Professors Susanna Pelagatti (UNIPI) and Audny Anke (UIT/UNN), it was agreed that introducing usernames and passwords would be too difficult. Options like Google Firebase and other tools or expansions for Unity were considered but deemed not fitting.
For now, the user selection is based on trust, meaning the users could potentially use each other's accounts if misbehaving or not under supervision.
The welcome panel added to the application is also designed with complexity in mind, opting for few but essential functionalities. The user can either create or select an account. The design is slightly guiding in its layout, since participants are highly likely to only generate one user in the application and keep to it, this button is the least prominent and smaller in size. Actual selection of users will be the most common scenario, hence making this button bigger and more centered on the screen natural.

7.1.8 Requirement 8: Keeping a familiar design layout

During this thesis, all added panels and buttons have followed already implemented design and symbol, with the intent to keep the application as familiar throughout as possible. Both colors and shapes retain a familiar pattern to reduce the possibility of confusion and make for a pleasant experience altogether. While traversing the application's functionality, at no point will the user notice that it is designed in two separate installments.

7.1.9 Requirement 9: Visual and audio stimuli

In instances where milestones such as rewards or progression are achieved, it is important not to overburden the user with feedback. With a game environment with visual, audio, and text notifications, it was essential to keep these elements as dispersed as possible. Guiding and information are kept consistent and easily understandable while the user progresses.

7.1.10 Requirement 10: Assistive technologies

Assistive technologies were a part of the first installment of AGA and are rightfully a part of this one. In added features and panels, the use of TTS and visual guidance has been upheld. The tutorial panel has also been improved and updated with explanations to new features.

7.1.11 Requirement 11: Pet companion rewards

The animal reward system is in its infancy. The user may unlock two different pet companions so far, being either a chicken or cat. Getting the functionality correct was considered the most critical part; additional pet companions can be added later as they are assets-packages in Unity.
When the user progresses in exercises and is rewarded a certain number of stars, these stars eventually unlock pet companions. First the chicken after tree stars, then a cat after six. These parameters can easily be altered or changed depending on future feedback, Once a pet companion is unlocked, it will appear on the user's main panel. In the future, these features could evolve and connect with the token-reward idea pitches by Ole and Frank at Kvaløya VGS. If the user has a certain number of points, rather than getting a specific pet companion, the user could choose their rewards as they progress. This is a much more engaging concept that automatic reward mechanics.

7.2 Feedback and results

While there has been much good feedback from the PA-ID project group and special educators at Kvaløya VGS, it would be preferable to run a more realistic test environment with a larger group of participants. With the application in daily use by individuals with ID, it will undoubtedly give much more nuanced and accurate results. Obtaining feedback from individuals with ID would be a valuable source of information regarding their interests, what they like and what they do not like. Such an environment would greatly benefit development and general understanding.

From all the above mentioned, the results and feedback are on the positive side. The application has grown tremendously throughout the project; the application scored well on the system usability scale, and special educators at Kvaløya, indicating that the application is on the right path.

7.3 Answer to research Problems

7.3.1 Main research problem

How can we create an avatar-based game application that promotes physical activity through motivational mechanics that is suited for people with intellectual disabilities?

The goal of the project was to create a game-like environment, utilizing avatar-based elements and exercise in a way that motivates the user into participating in physical activity. The main focus group is on individuals with mild to moderate intelletual disability. The solution provided in this project is a exergame for mobile devices (smartphones and tablet) which apply motivational mechanics such as point systems, rewards, competition and positive reenformence. The design choices made throughout the development is based on relevant literature gathered in the literature review, weekly feedback from the project group (see section 1.2) and special lecturers at Kvaløya VGS.

By creating a exergame with great usability, low complexity and good accessability the main drive is to engage is users into a healthier lifestyle. The use of avatars in a game-like environment together with motivational mechanics is intended to be more fun, motivating and encouraging then other more idle activities.

In the future, when the restrictions on social events are more lenient, a bigger testing evironment will open for further implementation of interactive functionality such as the active exercise. Feedback from caretakers and family is good, but being able to interview actual users will prove imperative in this aspect. With the current pandemic is it difficult to do small but effective changes that might benefit users in the actual game environment.

7.3.2 Sub problem #1

With the application in use, how do we make it engaging enough for the user to return on a regular basis?

In the first installment of the AGA application the core functionality for physical activity as created, it included a total of six different exercises (Burpees, Situps, Jumping jacks, Chicken dance, Squats and samba). This was a very important step as any further functionality can be connected to it. It is the only way for the user to progress within the application, meaning that exercises require physical activity, which in turn is rewarded by points. In this installment, the majority of core functionalities have been re-worked or further implemented into a coherent and more complete system.
More motivational factors have been added, not only in the sense of rewards but also on a personal level with the introduction of individual users.
With personal avatars, individual progression and more content during progression, the engaging elements are strengthened while giving the user more activity to participate in when playing. These new functionalities and elements that will undoubtedly increase engagment and returning rate of users on a daily basis.

7.3.3 Sub problem #2

With the application in use and returning users, how do we collect health data without compromising the user experience?

With the newly added functionality allowing for multiple users within the application, the amount of valuable health-data has grown substantially. This is achieved by implementing an easy-to-understand and simple user-creation, which is void of complex steps often associated with it. No usernames or passwords are needed, effectively adding close to zero complexity to the application and its users. It could be possible to utilize fingerprint scanning or facial-recognition as an added security step in the future. Additionally, significant efforts have gone into structuring the application for future data collection.

7.4 Research method

The initial research method was computing as a discipline, as it a very well-documented method. The discipline is structured and divided into clear segments making it easy to understand and follow. Throughout the thesis duration, the discipline became a hybrid where the segments cycled several times, almost in a loop-like manner. This was in order to be agile and continually improve on solutions, reiterate over functionality, and in the end, deliver a solid product.

7.5 Literature review

With a literature review conducted in the previous installment of the AGA application it was considered not beneficial to do a completely new review of all research material, but rather all new material since 2018.
The literature review in this thesis contains all newer material from the time period 2018-2021. With such a narrow field, unique requirement and modern approach (serious exergames) the results are quite few. The review concluded in seven new articles that add to the earlier material gathered. A application review was also conducted, here the Moviecycle and CorpOperatio was reviewed [12, 28].

7.6 Design process

The design process was plagued by a constant re-working of solutions, both in regards to unity hierarchy and structuring of the actual code and scripts. Initially, the plan was to separate the application into several independent scenes, which is the intended way of structuring games in Unity.
Unfortunately, after much reconsideration and several failed attempts, this was considered not feasible with the time at disposal. The approach with one-scene-hierarchy was continued as the design was structured in ways too time-consuming to refactor or restructure. As mentioned in the research method section, the design process became more of a looped activity, where elements throughout this thesis were re-worked numerous times to find the best solution.

7.7 Testing

Testing is a huge part of developing software for any user group, especially when the user group has different functioning and needs. How the user perceives the functionality and features might be very different than the developer might initially think. Because of this, testing is crucial, and feedback from any type of real-world testing greatly benefits the development of the application.
During the meeting at Kvaløya VGS, special educators (Frank Caglar-Ryeng and Ole Nerum Hatlen) and supervisor (Tone D. Aanstad) gave more insight into ID then ever imagined in such a short period of time.
Unfortunately, the COVID-19 pandemic put restrictions on test activities of this nature. The abundance of great input and advice from the project group (see section 1.2) helped tremendously. Being able to conduct a meeting and gather additional information during the visit at Kvaløya VGS was more then one could hope for given the restrictions in relations to COVID-19.

8

Conclusion and Future work

8.1 Conclusion

As with any project, the ambitions are high, creating and completing all the desired functionality and design planned.
There are often many failed attempts with the progression of development before a good and suitable solution is made. Aspects of the application are constantly changing, and consequently, so do the work required to achieve the set goals. Great examples of this are both the reworking of user customization and the multiple-users feature, as they both were born out of necessity and not necessarily planning.
The initial plan was focused on implementing a back-end connection to the mspider server database at UIT. However, as the development progressed it became evident that different elements of core functionality usually found in game environments were missing. The user customization functionality required considerable changes to accommodate multiple users and storage of avatar information.
Other elements such as extension of profile information and health-data metrics were considered more important in the application's current state. Without the added functionality and depth to the game environment itself, the application would contain very little health-data. The application does not communicate with a back-end server; however, all required structuring and scripts related to

exercises, user-profiles, and data structures have been reworked for this functionality in the future. The application now has a broader and more complete environment with depth that's engaging for the users. Offering features such as exercises, collectable rewards, personal progression, and entertainment in the form of a exergame.

8.1.1 Interactive technology and Physical activity

In this thesis, a closer look at the effects of combining PA with technology on mobile devices. By reviewing literature available,working closely with the project group (see section 1.2) and with people within the field of ID it is possible to design a modern approach to PA, using mobile devices. With enough testing, feedback, and refinement, it is quite possible to create an exercise game that has the right motivational factors to facilitate the recommended amount of weekly PA. While there are many aspects yet to be fully explored, with enough knowledge and dedication, many of these can be solved with already existing technology.

8.2 Future work

With progression of the project, many elements arose that one might have wanted to solve differently or considered a logical next step. Below are some of the prudent elements that have come to surface during development.

8.2.1 Application refactoring

Upon receiving the project in September of 2020, I was a first-timer to the Unity framework. Being such a complex tool, it took quite a while to grasp the concepts within the framework. After many guides and tutorials, it became apparent that one step in the "unity handbook" had been overlooked, the utilization of scenes.
Unity is, by default, designed to divide whatever game is being designed into several smaller tangible scenes. Each scene has a canvas that may hold a multitude of panels. This allows us to split the game into smaller, more manageable pieces during development while also spreading the application load as each scene only holds its own game objects.
In AGA, this was not done from the beginning, leaving us with a single scene containing all game objects and elements. The proposed solution would be to re-factor the very structure of the application, dividing it into multiple scenes. By doing this, the application could have a start-menu scene, user creation

scene, main game scene, and exercise scene. As the application grows, it will demand more from the device if not split into segments to share the overhead of elements and game objects.

8.2.2 Additional assets

Throughout the duration of the project, the Unity asset-store was scrutinized in hopes of finding good additional assets that would work well with the existing avatars . While there are hundreds, maybe thousands of assets available on the Unity store, it was hard finding something suitable with the current implementation (see figure8.1).
Only assets of a certain quality were deemed fitting, with certain criteria in relation to design. Since the application is aimed at youth, we wanted teen or youth models, not adults or babies.
We also want casual or exercise clothing, not suits for an office environment or chainmail for a post-apocalyptic scenario. Animals and pets was also searched for, but for some reason they either had less-then-suitable designs or minecraft-polygon designs.

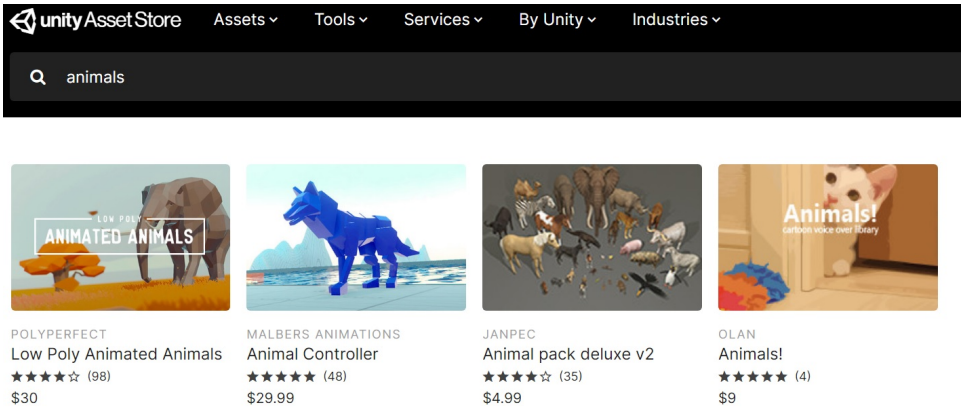

Figure 8.1: The unity asset store has many packages available.

8.2.3 User handling

There are many improvements that could be made to the handling of user-profiles and data. Usernames and passwords might not be suitable for this application, but Unity has several options within its framework that might be. Solutions such as fingerprint-scanning or facial-recognition could alleviate some of the complexity while adding the wanted security. These are obtainable assets in the Unity store, with comprehensive guides for a working implementation.

8.2.4 Reward systems

While the reward systems added in this installment in majority is autonomous, it was suggested that in order generate more engagement from the user, they should be given choices. Instead of rewarding the user based on a certain obtained number of points, stars, or tokens, we introduce prices for rewards. This way, the user may spend his collected earnings whichever way they see fit. The same system, some minor added touches, and we have a much more engaging feature right off the bat. Spoiler alert! Implementation has already started, hoping it will be a part of the next installment.

Figure 8.2: From the personal panel the user can enter the prize panel.

Figure 8.3: On the prize panel, users can trade in points for rewards.

8.2.5 Active Exercises

One very interesting element brought up during the visit to Kvaløya VGS was the possible change to the active exercise. Currently, the exercise is started by the user and only ends when the user has decided. This is opposite to common practice in general exercise and physical activity where intervals are well established. Instead, Frank, lecturer in gymnastics, opted for a solution where the user decides on the total duration of the exercise before starting it. This way, there is a clear end or goal for the exercise, making them more intervals than continuous PA.

8.2.6 Cross-project merging

With several sub-project of PA-ID retaining similar features, it would be possible to have a cross-project merging of user-data. Both CorpOperation [28] and

MoviCycle [12] have animal-park or pet-companion like rewards or features (see figure 8.4 . What would limit these factors from transcending the individual applications if they all communicate with the same back-end server at mspider? This would have further motivational and engaging factors on the users as they can transition between the application and still retain progression. Something to contemplate in future efforts!

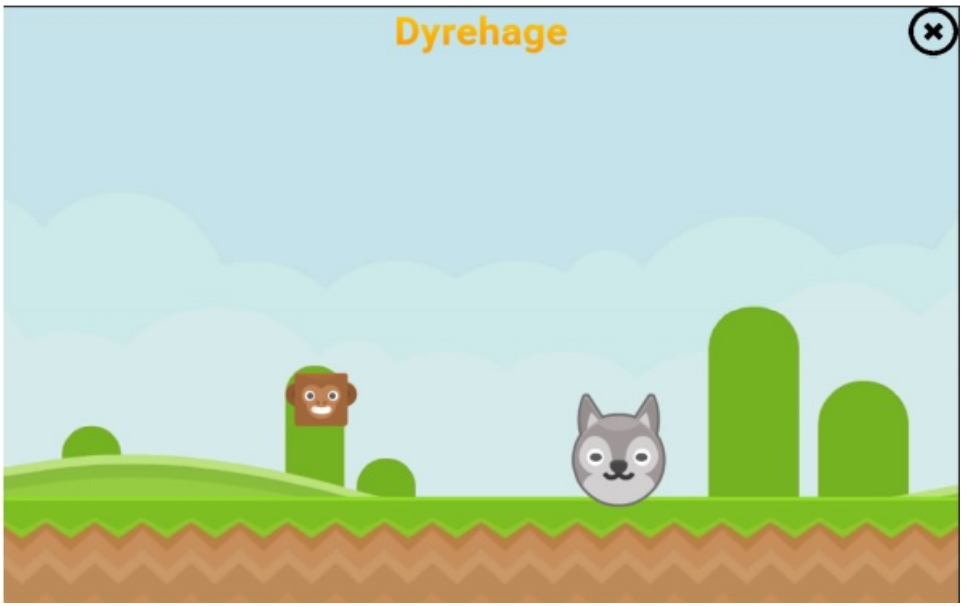

Figure 8.4: "Animal Park" from MovieCycle [12]

8.2.7 mSpider backend

While the communication with mSpider sadly fell short in this installment, I feel confident that very little testing would be necessary for the next installment to implement this feature. Much of the needed structure is, as mentioned, already implemented to handle the actual transmission of data, but as time will not allow for sufficient testing towards the server, I opted to finish other aspects within the application that had a greater overall impact on the finished product. [14]

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Appendix A - questionnaire (Norwegian)

6. Jeg syntes at det var for mye inkonsistens i systemet. Det virket ulogisk.

Sterkt uenig				**Sterkt enig**
1	2	3	4	5
○	○	○	○	○

7. Jeg vil anta at folk flest kan lære seg dette systemet veldig raskt.

Sterkt uenig				**Sterkt enig**
1	2	3	4	5
○	○	○	○	○

8. Jeg synes systemet var veldig vanskelig å bruke.

Sterkt uenig				**Sterkt enig**
1	2	3	4	5
○	○	○	○	○

9. Jeg følte meg sikker da jeg brukte systemet.

Sterkt uenig				**Sterkt enig**
1	2	3	4	5
○	○	○	○	○

10. Jeg trenger å lære meg mye før jeg kan komme i gang med å bruke dette systemet.

Sterkt uenig				**Sterkt enig**
1	2	3	4	5
○	○	○	○	○

Vennligst fyll ut det alternativ som passer best til din opplevelse etter å ha brukt systemet.

1. Jeg kunne tenke meg å bruke dette systemet ofte.

Sterkt uenig **Sterkt enig**

1	2	3	4	5
○	○	○	○	○

2. Jeg synes systemet var unødvendig komplisert.

Sterkt uenig **Sterkt enig**

1	2	3	4	5
○	○	○	○	○

3. Jeg synes systemet var lett å bruke.

Sterkt uenig **Sterkt enig**

1	2	3	4	5
○	○	○	○	○

4. Jeg tror jeg vil måtte trenge hjelp fra person med teknisk kunnskap for å kunne bruke dette systemet.

Sterkt uenig **Sterkt enig**

1	2	3	4	5
○	○	○	○	○

5. Jeg syntes at de forskjellige delene av systemet hang godt sammen.

Sterkt uenig **Sterkt enig**

1	2	3	4	5
○	○	○	○	○

Appendix B - User manual (Norwegian)

BRUKERMANUAL FOR AGA (Activity Game Avatar) 2021

Startpanel:

1. Er brukeren ny i AGA, trykk på “Ny konto”-knappen.
2. Har brukeren konto, trykk på “Spill”-knappen.

Ny brukerpanel:

1. Nye brukere lager sin egen unike karakter før spillet starter.
2. Gi brukeren et navn.
3. Oppgi alder (alternativt).
4. Velg karakteristikker for avatar.
5. Trykk på “Start”-knappen for å starte spillet med den nye brukeren.

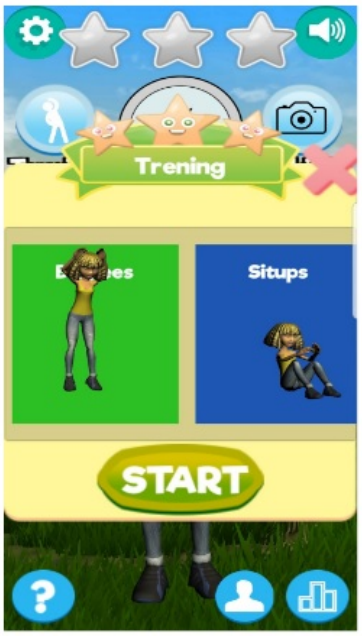
Eksisterende brukerpanel:

1. Bruk høyre eller venstre pil-taster for å velge en eksisterende konto.

2. Når riktig konto er funnet, trykk på “Start!”-knappen.

Hovedpanel:

1. På hovedpanelet har brukeren tilgang på alle aktiviteter.
2. ”Trening”-knappen viser brukeren tilgjengelige øvelser.
3. ”Ta bilde”-knappen tar bilde og deler fremskritt på sms eller i sosiale media(Facebook etc).
4. ”?”-knappen forklarer funksjonalitet i applikasjonen med tekst og audio.
5. “Person”-knappen viser brukerens progresjon(poeng, treninger etc).
6. “Highscore”-knappen viser brukerens progresjon opp mot andre brukere.
7. Grønne knapper i toppen styrer Instillinger og lyd.
8. Stjerner i toppen indikerer progresjon.



Trenings panel:

1. Velg blandt syv forskjellige øvelser.
2. Når ønsket øvelse er valg, trykk på “Start”-knappen for å begynne treningen.
3. Rød “X”-knapp lukker panelet.

Aktiv trenings panel:

1. Når en trening er aktiv kan brukeren avbryte treningen med “Avbryt”-knappen.
2. Når brukeren anser treningen som over, trykk på “Ferdig”-knappen for å avslutte.
3. Ved endt trening sendes brukeren til hovedpanelet hvor poeng blir tildelt.

Personlig progresjon panel :

1. Alle poeng, premier, stjerner og treninger kan følges av brukeren på eget progresjons panel.
2. “Til premier”-knappen fører til premier panelet(enda i utvikling).
3. Rød “X”-knapp lukker panelet.

Premiepanel :

1. Basert på poeng samlet av brukeren kan brukeren selv velge sine premier fremfor automatisk tildeling.
2. Se totale poeng tilgjengelig for kjøp av premier.
3. Rød “X”-knapp lukker panelet.

Highscorepanel :

1. Se brukerens poeng opp mot andre spillere.
2. Her regnes kun poeng, ikke premier eller antall treninger.
3. Rød "X"-knapp lukker panelet.

Instillinger panel :

1. Se eller endre navn satt i navn-feltet.
2. Se eller endre poengmål for brukeren.
3. Se eller endre treningshastighet.
4. Lagre eller avbryt endringer med "Avbryt" eller "Lagre"-knappene.