Augotchi: The Augmented Pet

Exploring virtual companion design in Augmented Reality games

Master's thesis in Interaction Design

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Abstract

When designing a digital game, the possibilities in terms of functionality and visual design are endless, which makes it difficult to find the optimal solution. This is especially true when exploring the possibilities of new technology or trends, where standards are yet to be established. One such technology is Augmented Reality (AR), which combines digital content with information gained from the real world. The focus of the Augotchi project is the design of a game where the core feature is a virtual companion. The other essential core feature of Augotchi is the global positioning system (GPS) integration and the utilization of real world geography, putting an AR aspect into the game. This project explores how to design a virtual pet being featured in a location-based AR game for mobile devices.

This thesis covers topics such as provoking emotional engagement in users, involving users in the design process through co-design workshops and evaluating the results. In this report, in depth descriptions of the methods used will be explained, the tools that were utilized will be covered and an extensive description of the final result will be presented. This report provides an overview of what was found in relation to developing such an application, and what questions may arise during the development of a similar game. One of the main topics of discussion revolves around the largest problem that arose during the project, which was the acquisition of external testers. Other topics of discussion include the implications of various features and the impact that location-based AR games might have on society.

Keywords: Augmented reality, virtual companion, Tamagotchi, application development, co-design, game design, prototyping, iterative development

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Another big thanks goes to the eight individuals who took their precious time and participated in the co-design workshops, as well as the evaluation session. These people also provided us with valuable feedback throughout the development. Without these contributions, this thesis would not have been possible.

We would also like to thank our colleagues at Far North Entertainment for providing us with an office space, as well as the web hosting service used for Augotchi. Furthermore, they allowed us to take time off from work, whenever needed, in order to complete this thesis.

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1 Introduction

The company Far North Entertainment, which both thesis students are part of, is a startup company active in the video game industry. This being the case, the company is looking for new concepts and prototypes that might turn into its next big project; it has so far specialized in virtual reality (VR) games, but is also interested in exploring new areas within digital entertainment. Augmented reality (AR) is one such area that has shown a lot of promise lately, and it is also related to VR, which makes it a natural subject of interest for Far North Entertainment. One of the biggest hits in mobile game history is Pokémon GO, an AR mobile game in which players collect magical creatures found in the real world, which became a worldwide phenomenon upon its release [2, 3, 4]. Not only did it reach over half a billion downloads in just two months [2], it also became a worldwide news story [4], bringing AR games the attention of the masses. In short, there seems to be huge potential in the mobile AR market, which means it is also interesting from a commercial standpoint.

The thesis will therefore consist of developing a prototype of a mobile AR game. The name of this prototype is Augotchi, which is a combination of the words *augmented*, as in augmented reality, and *Tamagotchi* [5] , which is the game that has provided the main inspiration for Augotchi's gameplay. Mival et al. [6] describes the Tamagotchi as an egg-shaped electronic device that features a virtual egg, which hatches and becomes a creature that needs to be taken care of by its owner. A virtual pet, so to speak. The name Augotchi thus reflects the two components which are studied in this thesis.

1.1 Aim

The thesis will revolve around exploring AR game design in order to create a better understanding of how such an application should be developed. The main aspect of the application, and hence the thesis, will be to create a game in which the player's relation to a virtual pet is the core feature. For example, in Pokémon GO, thousands of creatures are collected, filtered by power level and then discarded by the player. There seems to be little emotional connection between the player and the creatures he/she has caught. What if all the player's energy was to be funneled into one single creature instead, similar to a Tamagotchi? [7] Does this have a significant impact on how the player views the game and what it is about? These are just a couple of the questions that have been fundamental to the initial idea of the thesis, which research question is as follows:

> What game components are important when designing a virtual pet for mobile AR games?

The main goal of the thesis has been to formulate a set of guidelines and/or pitfalls that could help developers in designing an AR application built to emotionally engage people. While this is the means of achieving the main goal, the aim is to explore ways to develop

a successful entertainment product. Note that it is not obvious that, just because an application is emotionally engaging, it will thus lead to an improved user experience. However, this is the underlying assumption which resulted in the overarching theme of Augotchi.

In order to find answers to the research question, a mobile game prototype was developed. Throughout its development, both qualitative and quantitative data from user testing, co-design workshops and evaluation sessions were gathered, in order to later draw conclusions regarding what is good or bad practice when developing an application that, to some degree, relies on emotionally engaging the user. In this report, the study of the theory surrounding relevant subjects is presented, as well as the methods for how to perform the development and user research. Furthermore, the technical foundation of the game is described. This is followed by the three main chapters which describe the process, the results of the thesis and a discussion surrounding the project.

1.2 Delimitations

The result of the thesis is a mobile game prototype which features a virtual pet, AR being the fundamental technology used. The content of the game, and the technology utilized, are of course highly intertwined. Hence, one goal of the thesis will be to find out in what ways the two may affect each other, and determine how to capitalize on it. Virtual reality (VR) and mixed reality (MR) are other technologies that were considered early on, but due to time constraints, VR and MR are not part of the prototype. VR and MR are further described in Section 2.1. AR features that revolve around the projection of the virtual pet in the camera was also considered, but due to technical constraints, which would complicate the recruitment of testers, this feature had to be neglected.

1.3 Stakeholders

The stakeholders for the project are the following:

- Far North Entertainment - As described in the introduction.
- The students - As part of Far North Entertainment, and as students who have acquired new knowledge and experience through their work on the thesis.
- The Users - The people who have tried out the Augotchi application, and who will potentially use it in the future.

2 Background

In this section, the background of AR mobile games will be briefly presented. The technology will be more thoroughly described and compared with similar concepts, and some of the mobile AR games that already exist on the market are presented.

2.1 Digital Reality

Before describing in detail what AR is and how it can be used, the different forms of digital realities will be briefly presented. These are Augmented reality (AR), Mixed reality (MR) and Virtual reality (VR). In this thesis, the focus has been AR technology, with some influences of MR. VR has not been touched upon at all, but the comparison of the different concepts might clarify what AR is, and what it is not. AR can be defined as:

> "Computer-generated content overlaid on a real world environment" [8]

This is done by either utilizing data from the real world to dictate what happens in an application (for example GPS data or camera data), or by projecting digital or virtual images/objects on top of the real world through the use of a camera or similar. In contrast to AR, is Mixed reality. MR can be defined as:

> "Virtual spaces where real world objects or people are dynamically integrated into virtual worlds to produce new environments and visualizations where physical and digital objects co-exist and interact in real time" [9]

This may be achieved by, for example, mapping the position of an object and placing a similar looking object in the virtual environment, with the same relative position to the player as the real world object. The benefit of this is that the user can physically interact with the virtual and real object (the "MR" object) in the virtual world without seeing the real object at all, creating the illusion that the virtual object is actually real.

The line between AR and MR is not clearly defined, however, and there is no exact description of what distinguishes the two. One way of thinking about it, based on the previous quotes, is that AR tends to enhance the real world with virtual data, while MR tends to mix real world data and virtual data to bring forth a whole new experience [10]. However, the usage of the term MR seems to become increasingly obsolete, in favour of AR, effectively merging the two. The reason behind this is, as mentioned previously, that the line between AR and MR is quite diffuse. Hence, people tend to call all forms of both MR and AR, just AR [11].

The third concept is VR, which is more straightforward to explain. In VR, there is no connection to the real world whatsoever. The user, of course, still exists in real space

and might use hardware controllers, motion-tracked or not, but this is not enough to deter from the essence of VR. As long as the digital world that the user is immersed in lacks real-time information about the real world, it is called VR [12].

2.2 Mobile Augmented Reality Technology

AR, the transferal of real-time data, from the real world, into the contexts of digital applications, has become popular in digital entertainment, and in computer science in general during the last couple of decades [13]. Human-computer interaction has traditionally been based on the mouse and keyboard setup, which is proven effective for navigating through complex systems, managing data and playing games designed for the setup, but which is also limiting in how and when it is used [14].

With the arrival of smartphones, some of the limitations regarding where and how digital applications are used has been diminished, and this has opened up possibilities in what these applications may do. However, many mobile applications still function similarly to those on computers, with an on-screen keyboard for data input, and finger taps acting as "mouse" clicks. But smartphones do have something that desktop computers, and even laptops, do not have: a comparatively high level of portability and ease of access, making them usable anywhere at any time without much effort from the user. Combined with a wide array of technological features, including cameras, GPS, haptic feedback and internet access, the smartphone is more versatile than a traditional computer [15, 16].

The versatility of the smartphone has opened up possibilities in designing digital applications, one particular branch being AR applications. The fundamental idea of AR is to take real-time data from the real world, such as images or video, and project a digital layer onto it, hence, bringing virtual information to the real world: augmenting reality [13]. A classic GPS navigation system can be seen as an AR application, as it presents the user's position in the environment of the real world, with extra functionality that aids the user in finding her way to a desired destination. So, although this concept has been around for decades, it has never been as accessible as now. Some of today's applications use GPS and camera data for certain features, including navigation, public transit travel planning and social networking. Furthermore, AR has also been utilized in the development of games [17].

2.3 Augmented Reality in Mobile Games

One of the pioneers of the mobile AR games industry is Niantic Inc [18], which developed the games Ingress [19] and Pokémon GO [3]. Ingress, a game in which the players act as agents and battle each other in a global war for domination, has more than ten million downloads on Google Play alone, which is a respectable number. But few, if any, games can compete with the initial success of Pokémon GO. Only two months after its initial

release, Pokémon GO was reported by Niantic CEO John Hanke to have been downloaded over half a billion times [2]. Niantic approaches the AR concept from a new angle. Rather than projecting a digital layer upon the real world in order to provide useful information more effectively, they use the data in order to transform the real world into something completely different. This is the case in both Ingress and Pokémon GO, where the game world is set in the real world in terms of geography, but where the contents of the game world are completely fictional. Suddenly, energy portals and magical creatures are literally scattered across your neighborhood, and with it comes "real" secret Ingress agents and Pokémon trainers that you can meet and interact with [3, 19]. The success of Pokémon GO has proven that AR games have great potential, and that people in general are open to the concept of playing a game in the "real world". However, much is yet to be discovered, as the genre is relatively young.

Another game genre that exists in a number of variations on a multitude of platforms is the Tamagotchi, a digital pet simulator which features a virtual pet, with needs that the player has to meet in order for the pet to survive and thrive [20]. This genre has also been adapted in AR, vaguely in Pokémon GO which arguably shares some similarities with the Tamagotchi, but also more directly, such as in Curiopets for iOS, a Tamagotchi-Pokémon GO hybrid, which features real world location integration and projection of the pet within the camera image [21].

The combination of the Tamagotchi and AR makes for a game concept with a number of variables that might affect the user experience and the motivations of its players. The progression system for both player and pets, based on experience gathering, item collection and the growth of one's digital companions, is one such aspect. Competitive features, such as battling in Pokémon GO or playing games with friends in Curiopets, is another one. Social interactions with other people, that might occur when playing in the field, is a third one.

Another possible one, which is the focus of this thesis, is the emotional investment and attachment that the player has to his/her pet(s). How does this affect the player's motivation to keep playing the game? If the pet is at risk of becoming sick due to inactivity of the player, will this motivate the player to take an extra walk around the block in order to keep the pet healthy? What variables matter when the player decides to, either care for the pet, or leave it be? Is there any emotional investment at all from the player's side in such a game, or is it just pure entertainment value that keeps him/her interested? These are just a handful of questions that could be valuable for any game development project with Tamagotchi influences.

2.4 Formal Game Analysis

Exploring already existing applications within the AR game genre was deemed important in order to understand what has already been done within the field. Such background research proved valuable insights throughout the Augotchi project, since it gave us some-

thing concrete to compare the prototype with, as well as a rough guideline when making decisions regarding the features of the game.

The background research, in this case, consisted of a formal game analysis in which the game features of Pokémon GO and Ingress were taken apart and analyzed in order to identify their building blocks in terms of game play patterns and game mechanics. This section will present the results of this formal game analysis. The patterns have been derived from analyzing the different components of the two games. The different patterns are described in a generalized way. In some cases, patterns are hard to describe without using in-game terminology, and therefore, a vocabulary for these terms will be provided for each game. There will be some design principles of both games that are identical, or at least similar to a great extent, and these will be further discussed in the conclusions section of the analysis.

2.4.1 Formal Game Analysis Conclusion

Pokémon GO and Ingress have a lot in common. This is no surprise, since the games belong to the same genre and are made by the same people. In essence, the games are the same in most aspects, but with two major differences. In Ingress, the player must compete with other players in order to progress in the game. To do this more effectively, the player has to interact with other players. This is something that is not necessary in Pokémon GO, which allows the player to play on his/her own and still reach the late game. The second major difference is the collecting aspect of Pokémon GO, where the major part of the game revolves around expanding and improving the player's personal collection of Pokémon.

Both games could almost be described as having two main phases when it comes to the GPS map game play, one which is largely identical, and one which differs a lot. The common phase is the resource gathering phase, which has the player move around to different portals, or pokestops, in order to gather items from them. Items have the same role in both games, and act as fuel for the player, since most player actions require these items. The second phase is related to how items are used. In Ingress, items are exclusively used in order to either build up portals for the allied faction or destroy enemy portals, and items are meant to be consumed and used as effectively as possible. In Pokémon GO, some items work in a similar way, but the effects of some items are also long-lasting. For example, In Ingress, you might build a strong portal with rare items, only to see it being destroyed the next second. Ultimately, your consumed items did not have a significant impact. In Pokémon GO, if you spend a lot of stardust, candy and other valuable items in order to empower one of your Pokémon, it is a no-risk, long-term investment. Augotchi might be a combination of the two, and it will be important to keep both aspects fun and challenging:

- Since Augotchi will feature a pet which needs to be constantly taken care of, it can be viewed as a constant battle against the system, where the system continuously

draws the pet closer to death, and the player continuously tries to protect it. This is similar to the constant battling in Ingress, the difference being that the decline of one's pet's health will be predictable, while the actions of enemy players in Ingress, are not.

- Since the goal of Augotchi will be to keep one pet alive and thriving, it is also a long-term investment, like in Pokémon GO. As long as you do a good job in taking care of your pet, there is no risk of losing it, or seeing it get hurt. The question is then: what happens beyond just keeping the pet alive? How far up the positive axis can you push it?

One noteworthy similarity between the games is that they both lack a win or lose state. The reasons behind this are not obvious, and are subject to speculation. Ingress and Pokémon GO have both been on the market for years, and some of the people that started playing on day one still continue on the very same game session. The games are designed in a way which makes them, in practice, impossible to fully complete. It seems like Niantic has decided that the classic aspect of "beating" the game does not fit the AR game genre, and that the developers want their players to be committed to the game in the long term. Of course, when you develop a game which is free and relies on in-game purchases, you want your players to never stop playing, so that you maintain a steady stream of income. But it does not explain why there are no rounds in the game, for example, by restarting the game state once every few months. If Augotchi is to feature the death of the virtual pet, this design principle is lost, but it is hard to pinpoint what it would mean for the players and the gameplay. In other words, two questions worth contemplating are:

- Should it be possible for the pet to die in Augotchi, given what is seen in Niantic's games, where no end state exists?

- If death may occur, how much does it take before it happens?

The way items work in both Pokémon GO and Ingress is also worth contemplating. The idea of having different rarities and power levels of items might be useful for Augotchi as well, if items are to be featured. In any case, there has to be a reason for the players to move around in the real world in order to justify the AR mechanics, and the collection of necessary items is a seemingly effective way to do this. The random generation of items is also an interesting aspect, since it makes the item gathering less predictable, and more exciting. The limited inventory space is probably connected to the issue of making people walk as well, since it makes sure that a player cannot intensely gather items for a couple of days, in order to not gather items again for another month. The constant character progress of both games might also be related to maintaining the motivation of the players. The issue of motivating the players to move around in the world is one that Niantic has obviously put a lot of thought into solving, and the Augotchi concept will have to solve this issue as well. Hence, a couple of questions need to be answered:

- What are the fundamental motivators for a player to move around in the real world?

- How can the motivations of the player be maintained over time?
- What are the micro-goals and macro-goals of Augotchi?

Macro-goals are essential to any game; it is what the player ultimately strives to achieve and defines the point of taking actions within the game. Ingress only has one identified macro-goal, and Pokémon GO has a number of possible goals that might be interesting to the player. An important structure to define for Augotchi is what macro-goals the players might strive towards, as well as what micro-goals they need to pursue in order to get closer to said macro-goals.

A full list of all design patterns found in the formal game analysis can be found in appendix A.

3 Theory

The theory section of this thesis will be dedicated to presenting ways in which a person may be emotionally affected by entertainment and games, and how this impacts said person's willingness to engage in certain activities. This section will also present already concluded research regarding relationships forming between people and virtual creatures, as well as how to design digital applications featuring a virtual creature in order to enhance emotional engagement.

3.1 AR - Benefits and Problems

The concept of AR differentiates from traditional digital applications in a number of ways. In this section, the possibilities and limitations of AR will be presented in order to better understand the implications of such technology.

One benefit of AR applications that encourage physical activity, is the positive impact they have on their players. According to the World Health Organization, physical inactivity is the fourth leading risk factor for preventable death worldwide [22]. With physical inactivity being such a major health problem worldwide, many search for answers for how to solve this. LeBlanc and Chaput write:

> "In July 2016, Niantic released what may be the most successful population level physical activity program that we have seen in modern history." [23]

This is an astonishing observation, not only as a credit to Niantic as the developer of Pokémon GO, but to the AR game market as a whole, illustrating the potential of the genre not only as an entertainment medium, but as a health benefactor. The interest in Pokémon GO decreases over time, just like any newly released game. However, data from Microsoft shows that the game may increase physical activity levels of its players by about 25%, which is a substantial increase [23].

While increasing the level of physical activity on an individual level, AR games are beneficial on a societal level as well. One of the areas in which the AR game genre might be helpful is with the activation of suburban areas that were previously not utilized to their intended potential:

> "Urban planners and designers have spent the last 50 years trying to activate unused public spaces, create walkable cities and encourage sociability through urban design. Pokémon GO has succeeded, almost overnight, to entice people of all demographics into the streets of cities around the world. In fact, many previously underutilized public spaces have suddenly become hot spots for all demographics, playing Pokémon GO and other similar augmented reality games (ARGs)" [24].

This means that the players of AR games are much more likely to wander areas where ordinary people would not often visit at all. This is beneficial for several reasons, the two most important reasons being that people see more of the city, and maybe visit stores that would otherwise suffer from low visitor counts. The second reason is that it might have people taking different routes, which means that the main routes that might otherwise be cramped and overused, will get some relief.

Even though there seems to be benefits to AR games, they might also pose problems. A new form of advertising illustrates the potential issues of AR. Due to players of AR games searching for virtual items at set locations, companies that benefit from a higher customer count may contact the game developers and make deals with them, in order to have them create in-game sites at the company's grounds, directing players to the shop through the game. Liberati writes the following:

> "We should not underestimate this contaminations between realities because it is a way to change our world indirectly. For example, this kind of hybridisation between realities could be used in order to change the relevance of places in the paramount reality by someone. A big brand could make agreements with the designers of these games in order to add value to specific places they are interested in like stores. By making a store a valuable place where Pokémon often appear, the importance of that place in the paramount reality changes according to the new value acquired in the game. McDonalds is one of the sponsors of Pokémon GO in Japan and they have agreement in turning every McDonald store into a "valuable" place for the game" [25].

While not an issue in itself, it may become an ethical issue if the user does not realize that this is happening. More problems that could arise in both a personal and grander scale is if users who are immersed in AR games do not pay attention to the world around them while playing. Even if most AR games have heavy warnings for this kind of behaviour, it is still non-negligible that games like these will cause accidents. Studies estimates that the AR game Pokémon GO caused over 100,000 traffic accidents during its first year [26]. The notion that AR games can be dangerous is important to keep in mind. However, in a game that features GPS integration, people will inevitably be active in trafficked areas, which inevitably will lead to accidents.

3.2 Emotional Engagement in Entertainment Media

Emotional engagement is a vague term with a number of possible meanings. The emotional engagement of Augotchi refers to the virtual pet and its ability to emotionally engage the player. Hence, the term will, for the sake of this thesis, be defined as:

> The involvement of an agent, through the occupation and attraction of said agent's attention, by affecting that agent emotionally.

According to Bartsch & Viehoff [27], there are a number of reasons why people seek gratification by consuming media entertainment, reaching from simple emotional arousal to more abstract motivations such as self-improvement or relationship-forming. Some of the motivators on their list are:

Mood-management - Influencing one's mood, for example, by watching an action movie when bored, or simply keeping yourself distracted from negative thoughts.
Excitation transfer - The notion that high suspense, created by fear of bad outcomes, results in a gratifying feeling of relief when the ending is, in fact, happy.
Sensation seeking - Similar to mood-management and excitation transfer, but without any specific goal. Any sensational experience that triggers a particular emotional response to a high degree may be entertaining in itself.
Intrinsic motivation - The capabilities of the consumer of any media, including computer games and watching movies, should be challenged by the media in a balanced way, since this is essential to the consumer's willingness to continue the activity.
Relationship functions of entertainment - Entertainment has an ability to constitute different forms of relationships, such as parasocial relationships; a one-way relationship between audience and media figures, that act as an extra source of social and emotional gratification.

Bartsch & Viehoff [27] further classify said factors into two categories which are related to emotions and functionalities respectively. Making friends and letting out emotions that do not fit in everyday life situations, are examples in the functional category, with the emotional category containing the sensations of fun, thrill and being moved. These are not the only emotions that might be influenced by media, however.

Riva et al. [28] found, in their study of the link between emotions and presence in VR, that feelings of sadness, happiness, anxiousness and relaxation may be substantially affected by the nature of an environment in VR. They also found that a test subject's presence in the simulation increased with the magnitude of the emotional effect that the environment had on them. In other words, a neutral environment did not affect people emotionally, and therefore, they felt less present in the simulation. On the contrary, an anxious environment had a significant impact on both emotions and feeling of presence.

One way of getting people involved in media entertainment is the connections they share with the characters therein. Moyer-Gusé [29], in her analysis of entertainment-education in story-driven media, lists parasocial interaction and liking as two of five ways in which people get involved with the characters in media. Liking refers to the initial phase of involvement, where the audience member judges a character and determines, inter alia, whether the character is likable or not. Likeable characters may then be subject to parasocial relationships, which, as mentioned previously, refers to a kind of bond between a person and a media figure. It has been shown that people have the capability to perceive figures, with which they have formed parasocial relationships, as role-models, or even friends. Furthermore, she proposes that a character, with which a person has formed

a parasocial relationship, increases the persuasive power of entertainment-education, and hence, its ability to influence, amongst other things, the behaviour and attitude of said person.

Choi et al. [30] further strengthen the notion that bonding with characters is important when trying to achieve a higher level of emotional engagement, and that human beings tend to treat characters as social actors if said characters are showing signs of emotion, either by social cues or facial/body expressions. They further claim, in their analysis of facial expressions and engagement in decision making games, that:

> "These findings are tantalizing, because they reinforce more general findings that people treat computers as social actors when they include appropriate social cues." [30]

These findings are also in line with a theory known as the "Media Equation Theory" [31], which states that people tend to treat characters and places in media as if they were real people or real places. They further claim that people view computers, running even relatively simple code, as social actors. This relates to the concept known as anthropomorphism, which is presented further in Section 3.3.

In addition to the social aspects of consuming media entertainment, some of the factors of Bartsch & Viehoff's list are described as vital, for virtual games specifically, by Boyle et al. [32]. Challenge, exploration of virtual worlds and opportunities to form relationships are some of the pathways to game enjoyment, with challenge, followed by emotional arousal and excitement, being rated the most important by young people aged 18-24. Other motivations mentioned are information seeking and social interactions, as well as an increased enjoyment from knowledge of the subject of the game, as when playing a sports game while having extensive knowledge of said sport. Coulson et al. [33] compiles a list of motivations, when playing virtual games, in their analysis of emotional attachment and interpersonal attachments in video games. The list can be narrowed down into the following three categories:

Social motivations - Such as wanting to chat with other people, engage in activities with friends or even find new friends. This kind of person tends to be drawn to games in order to interact with others.
Achievement motivations - The desire to achieve something in games. Be it further developing a character by gaining levels, gathering equipment or completing a difficult task, such as defeating a hard boss, gathering all stars in a level or beating a worthy opponent in player versus player combat.
Immersion motivations - A willingness to immerse oneself in the world and story development of a game, as well as a desire to continue playing in order to see more of the story and take part in the plot. Immersion could also be fueled by curiosity, which makes the player want to further explore the world of the game and discover everything it has to offer. Another motivation is to avoid stress or problems the user experiences in real life.

The authors continued by studying the social and emotional attachments the players form with the characters of a game over time, and monitored the statistics. In their analysis, they conclude that researching relationships within virtual environments is, indeed, a legitimate endeavour [33]. It is important to note, however, that within the game that the authors used in their analysis, the characters that the test subjects formed attachments to were all human-like characters. Since the virtual pet in the Augotchi prototype will not necessarily be a humanoid creature, it is important to establish what the implications of a non-humanoid, and even non-living, pet would be.

3.3 Relationships with Virtual Companions

In 2006, in her research on mobile phones and their use, Jane Vincent [34] found that users may develop emotional attachments to their phones. She could identify an increase in gratification and satisfaction of users when they had their phones with them, and she could see an increase in anxiety, and even panic, when the users were apart from their phones. She further claims that phones have become part of people's lives, and that people share their problems, and even happiness, with their phones. It is interesting to note that this research was conducted long before the big breakthrough of smartphones [35]. Today, the number of smartphone users have increased significantly [36], and it is also easy to imagine that more powerful and versatile phones lead to an even greater attachment. It highlights the dominant role of technology in our lives, going from being a tool to being a substitute for human relationships [7]. The notion that people can form emotional bonds with an inanimate object, and not just humanoid beings, is valuable information. However, bonding with characters in entertainment, and bonding with a useful, technological device, cannot be assumed to depend on the same factors.

In any case, it has been established that emotional bonds may appear between human beings and characters in entertainment, as well as inanimate objects. A digital companion would be some kind of hybrid, an inanimate object which is simulated to express the behaviour of living things. What are the specific characteristics of human interaction with such a hybrid?

When human beings look at things they do not fully understand, they tend to apply whatever attributes they recognize in similar things, to the unexplainable objects. In extension, when looking at digital or robotical, animated objects, there is a tendency for human beings to relate what they see in the behaviour of the object to what they have seen prior in living things, such as animals, or even other human beings [37]. This method of applying known patterns of living things, to behaviour human beings perceive, but cannot explain, in non-living things, is called "anthropomorphism" [38], and it is fundamental to being able to form relationships with inanimate objects. An extreme example of anthropomorphism, is the "pet rock". In one study, 106 participants were each given a rock, and were asked to decorate it [39]. Approximately half of the participants painted a face on the rock, and about half of the participants claimed to have given the rock a personality, to some degree. The authors try to explain this outcome in the

following quote:

> "A possible explanation for the self extension results could lie in the form factor of the rock itself. That is, perhaps the spherical rock suggested a head, which in turn led participants to anthropomorphize the rock and attach personal meaning to it that they would not have attached to another less humanlike product" [39].

This hints that all it takes for a human being to anthropomorphize an object, is for it to, for example, have a round headlike shape. Indeed, the authors also claim that:

> "We showed that the simplest of activities, creating a design on a 'pet rock,' can lead to feelings that the object symbolizes the self" [39].

If a rock can be perceived as something more than just an inanimate piece of matter, may it also qualify for relationship forming with human beings? Jen Wrye [40] argues that, what constitutes a pet is not simply the relationship status between human being and living entity, such as a man owning a dog, but that an object's "petness" is based on emotional investment into said object. Furthermore, she claims that there is no inherent petness to any object. Hence, being a dog does not qualify more as a pet than being a rock with a painted-on face. In fact, the opposite could be true, since a rock with a painted-on face has an obvious connection to human investment, while an arbitrary dog might have had no contact with human beings whatsoever. In short, viewing human-pet relationships as a social construct, rather than a strictly defined relationship setup, makes it possible to view any object, living or dead, as a pet.

However, there are differences in how different objects are perceived, which might affect an object's potential to become, for example, a pet. A study made by Kahn et al. [41] shows that children treat a stuffed dog differently than an animated robotic dog. A particularly interesting finding was that, during the interviewing of the children, the results were very similar in how they thought they treated the robot and the stuffed dog. However, when they compared the actual recorded data, there were clear differences. For example, the children were much more prone to mistreat the stuffed dog. One explanation for this could be that the children have previous experience with soft and hard objects, and know that soft objects, in general, are harder to break. Additionally, the children could have been taught to be more careful around electronic devices. Although treating the robots more carefully, when asked, the children answered that they believed both dogs could hear to the same extent, but when actually looking at the data, the children were significantly more prone to give the robot verbal commands. Regarding these findings, the following statement was made, "AIBO" referring to the robotic dog:

> "Children also appeared to believe that AIBO was the sort of entity with which they could have a meaningful social (human–animal) relationship. Specifically, over three-quarters of the children said that they liked AIBO, that AIBO liked them, that AIBO likes to sit in their lap, that AIBO can be their friend, and that they could be a friend to AIBO" [41].

They continue by concluding that, while most of the children knew that the robotic dog was not a real living dog, it did not stop the children from conceiving and treating the robot as such. This further proves that when robots and computers show even minimal signs of social cues, humans tend to treat the computer as if it was a social agent [41]. That a minimal amount of social cues from a virtual object can affect the relationship forming between itself and its owner is further strengthened by Mival et al. [6]. They describe the interactions of the Tamagotchi as basic, since they only consist of pressing a few buttons, and point out that strong emotional relationships can still form between these virtual pets and their owners:

> "There have been cases of people treated for depression following the death of their creature, highlighting how a simple software algorithm based on four simple rules can truly engage people to form a relationship when correctly packaged." [6]

This claim is further supported by Bloch & Lemish [7], who claim that the Tamagotchi community has constructed the notion of a "virtual temple", where the players can go and leave offerings, or prayers, to accommodate those whose Tamagotchis have virtually left them, and that several support-chat groups exist for both owners of live and deceased virtual pets. This might seem absurd to some degree, and indeed there are skeptics that argue that real love can never be obtained from such a bond [42]. Nevertheless, it seems clear that there are strong emotional feelings involved in these human-virtual creature relationships.

3.4 Virtual Creature Graphical Design

One aspect of human beings that makes work more difficult for designers, is that they are really good at distinguishing what looks real and what does not. Furthermore, a phenomenon which makes this work even more complicated, is a concept known as the uncanny valley [43]. What this means is that, if something is very close to realistic, but only slightly diverge from what is to be expected, human beings often view the thing as appalling [33]. Some reasons why the uncanny valley problem appears may be that the character, while seeming alive, reminds them of death. Another reason may be the portraying of humanoid robots in popular culture, that are often viewed as having superhuman strength and evil intentions. Finally, it may be that they lack emotions and empathy, which reminds them of the fact that they are not alive, even though it looks like they are. Koschate et al. [44] further proposes that a solution to the problem of the uncanny valley effect is to increase the level of emotion expressed by, in this case, a robot. They also claim that empathy is a core element of humanness and therefore is important to simulate if one wants to create a character and make it as human-like as possible. It is to be noted, however, that the study was made using humanoid robots rather than animals, so a good question might be, does this apply to animals as well?

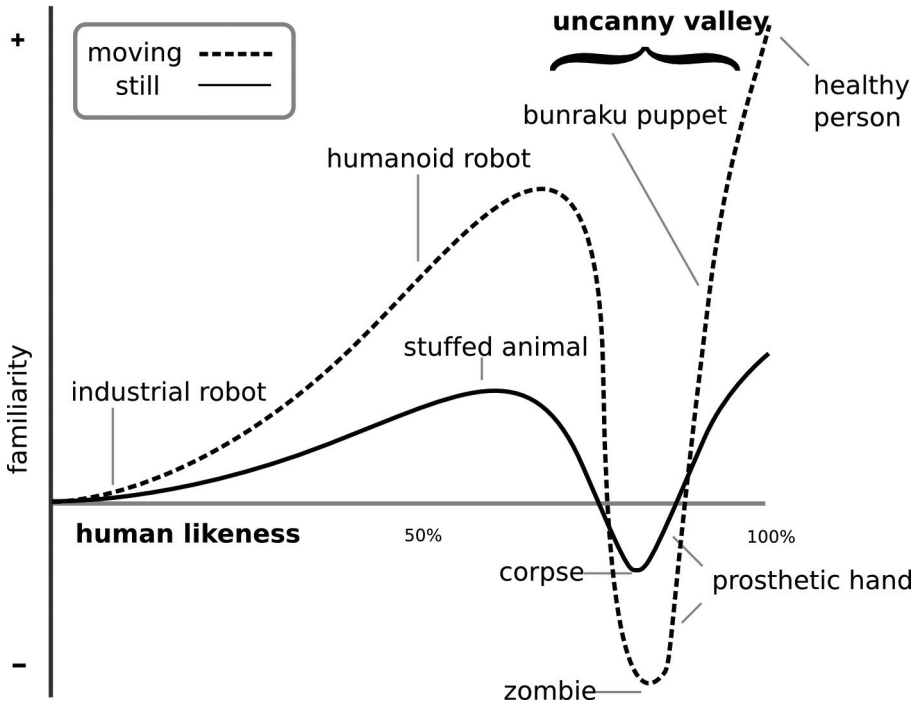


Figure 1: Mori's uncanny valley graph [1]

In a study, looking into the uncanny valley problem in virtual animals, Schwind et al. [45] shows that the uncanny valley problem is ever present in zoomorphic characters as well. However, they argue that the curve might look different. They found that photorealistic rendering gave a high level of familiarity, but also that toon shading (or cel shading) gave good results in familiarity, aesthetics and realism. They conclude that the cel-shaded cat, which was one of many cats rendered in different ways, is within the safe zone of Mori's uncanny-valley graph (Figure 1). To support familiarity, they also conclude that:

> "For game developers, this means that an animal character should not possess human expressions, emotions, or speech if a realistic animal character should be fully accepted." [45]

This means that the human expectation of how a cat should behave needs to be satisfied, and that adding human attributes to the cat in order to achieve a higher level of anthropomorphism only further increases the uncanny valley effect, since it is not what humans would expect of a cat. For example, adding facial expressions to an otherwise ordinary cat, is therefore bad practice, which stands in contrast to the research of Choi et al. [30], who claim that facial expressions in virtual characters are important in evoking emotional engagement in the user. This illustrates that there are indeed differences in how to effectively design a virtual animal or virtual humanoid character.

Schwind et al. [45] argue that there are two preferred ways of moving from the valley. The first way is to increase the level of graphical quality to a photo-realistic level, whilst maintaining the correct body ratios and matching the human's expectations of the animals (in behaviour and sound for example). The other method is to stylize or

abstractify the character to a level where you end up on the other side of the valley. Yet another note here is that, in the study, only cats were studied. However, it is argued that it is reasonable to assume that the same rules apply to other animal species.

Avoiding the uncanny valley is important in order to not create virtual characters that are directly visually off-putting to an observer. While important, it is only one topic of the theories on why characters are liked or disliked. Coulson et al. [33] claims that there are three critical factors involved when a player decides on if a character is likable or not: Physical attractiveness, Social attractiveness and Task attractiveness. The first property is simple, and refers to the character's visual appeal. Social attractiveness revolves around the personality of the character, and how it acts socially. Task attractiveness is arguably the most interesting one, since it has not been touched upon previously in this theory section. Task attractiveness measures how useful the character is in a situation, or in the game/setting as a whole. If a player finds a character useful, he or she is more inclined to like that character. When considering the personality of the character, the authors describes it as typically conceptualized in terms of five big personality traits, also known as the five factor model [46]. The traits of this model are: Openness, conscientiousness, extraversion, agreeableness and neuroticism. This theory does not apply specifically to virtual characters, but is used in describing human personality in general. However, it will not be further elaborated on here.

Choi et al. [30] points out the importance of emotional expressions, on the virtual character's part, when trying to evoke emotional engagement from the player. While relevant, this paper only talks about the connection in a humanoid-user relation and how the character's humanoid facial expressions influence the user. It is assumed that this could be applied to animals as well, but probably not to the same extent. Facial expressions in animals may be very hard to actually read as a human, but to animals, body language is more vital than to human beings. This means that, if the body language of the animals is recreated accurately when expressing the desired feeling, results resembling those of the authors' research might be acquired [30].

Emphasis should not be put solely on understanding the virtual characters, however. Coulson et al. [33] stresses the importance of understanding the player observing the character, as well as the character being observed, and that through understanding, the mapping between real and virtual people will severely assist in developing more effective, believable and entertaining virtual characters. The authors conclude that:

> "..,virtual characters evoke strong feelings, and with increasing realism of both graphical and psychological characteristics, designers and researchers need to focus not just on virtual characters' appearance, but on their utility, and how both of these are filtered through the lens of player motivation and personality." [33]

This further illustrates the importance of understanding what a player likes to see in a character, in order to make it likeable, or dislikeable, depending on the context.

3.5 Researching Emotional Engagement

One way to investigate human–virtual-entity interaction is described by Serholt & Barendregt [47]. They studied robots tutoring children, and the child-robot interaction that arose in such a setting. The study shows that children tend to reply to the robot as if it was a human being, for example, by using gestures, nods and facial expressions. The authors reached these conclusions by observing children interacting with a virtual tablespace and the tutoring robot, while recording the actions taken by the children. The observed behavioral cues of the children, such as gestures and where their gaze were, were then sorted and categorized. The study was carried out over a period of three and a half months, with most sessions ranging between 10-15 minutes, but there were also longer sessions of around 40 minutes. It is worth noting that Serholt and Barendregt's study was focused on children aged 10-13, which is a considerably different target group than the one intended for Augotchi. For Augotchi, the testers are planned to be at least young adults, and the different ages might vary. Another major difference is that a robot is a different kind of entity than a digital creature.

Direct observation and analysis of behaviour is one way to find out how effective an artifact is in impacting people emotionally. Riva et al. [28], when measuring the emotional response of people experiencing different VR environments, used two completely different methods in order to draw their conclusions. The first being questionnaires and the second being questions during observation of the participants. In their case, they measured differences in mood and immersion by asking the participants to fill out numbered scales. For example, the participant was asked to answer, on a scale of 1-7, to what extent the virtual environment was experienced as reality for the participant. Even though they could reach some conclusions, the authors point out that the sample space was quite small and that the usage of only self report questionnaires might be a liability.

4 Methodology

The Augotchi project was divided into a number of phases. The methodology changed from phase to phase, and the project consisted of four main phases:

- Concept development
- Minimum Viable Product (MVP) development
- Iterative process
- Project evaluation

Each of these phases consisted of various amounts of software implementation and design work. The concept development was pure design work, and consisted of various methods for refining the concept of Augotchi and determining what the application was supposed to feature and how it would look. MVP development was purely technical, and consisted of programming the first version of the application, which embodied the concept created in the concept phase. The iterative process phase was a mix between the two, where design work and technical implementation were performed in parallel, in order to refine and expand the application and the concept. Finally, a brief project evaluation took place, which was the analytic phase, where data gathered during interviews and co-design workshops, were analyzed and discussed. In this chapter, the methods that were planned to be used for the different phases are described.

4.1 Concept Ideation

4.1.1 Formal Game Analysis

The formal analysis of game play, which results were presented in 2.4, was based on the method described by Lankoski & Björk [48]. Such an analysis is conducted by identifying the objects, player actions and goals of a game, in order to identify its game play patterns and then analyze what the roles of the identified patterns are. Thoroughly describing the primitives (Objects, actions and goals) is key to discovering the implications that they have on the game as a whole. It is also important that the researchers have extensive knowledge of the game being analyzed, which requires the game to be played many times, or in the case of the games studied for this thesis, a substantial amount of time. The formal game analysis was expected to result in a deeper understanding of the two games, and specifically to make it possible to draw conclusions regarding Niantic's philosophy on the design of AR games featuring GPS map integration.

4.1.2 Quick online surveys

Online surveys is a method designed to result in data about a selected topic, and depending on the needs of a project, the topic can be anything. However, "Online surveys" is a broad term. "Internet or Intranet surveys" is one category of online surveys that are short and quick, as described by Sue and Ritter [49].

4.1.3 Brainstorming

One of the most important methods when conducting concept creation is brainstorming [50]. However, brainstorming is a broad term which includes a lot of different methods. One thing that is important, no matter what brainstorming method is being utilized, is to give the participants a question to answer. Brainstorming should always be a task where the participants are looking for an answer to a question, as it is severely harder to come up with good ideas if no question is present. These questions are commonly referred to as "focus questions", and they are were defined prior to each workshop, in order to gain the desired results. During the project, several forms of brainstorming [51] can be used:

- **Traditional brainstorming** - This is the general brainstorming method. It is designed to have a lot of interaction and encourage a lot of responses. Traditional brainstorming is done by asking the participants a focus question and giving them some time to answer out loud, while recording the answers.

- **Stickies** - This method utilizes post-it notes, on which the users write their answers to the focus question on, before putting the responses up on display for all to see. The upsides of this compared to traditional brainstorming is that it feels safer for the participant to not have to speak out loud in front of an often unfamiliar group. Additionally, the stickies method helps with neutralizing a dominant member of the group that could otherwise give a disproportionate number of answers. The drawback is quite small, being only that it slows down the brainstorming somewhat since it takes longer to write than it does to speak.

- **Grids** - This method, as the name suggests, starts with the host drawing a grid on a board. The grid may be 3x3, 4x4 or larger. The host then asks a focus question and the participants get some time to answer it. When they are done with the answers, the answer is written both in the header of column x and row y, meaning that the first person's answers are placed in column 1, row 1, and so forth. The task for the participants is then to cross the ideas in the rows and the columns, producing even more ideas. The positive things with this method is that it produces a lot of answers from only a few initial ones, and it keeps the group motivated to continue filling in the grid until all cells are occupied. However, the highly structured nature of this method can be intimidating to some participants, and additionally, if the focus questions are poorly designed, it might result in crazy ideas that might not

be so useful.

- **Paper swap** - In this method, the users take turns and collaboratively write several series of answers. The host reveals the focus question, and all participants write an answer on a sheet of paper. The paper is then sent one step to the left in a ring, so that all participants have swapped papers. Then the focus question is told again and the participants have to answer it a second time, while building on what is already written on the paper. This process is repeated until all participants have given input on all papers, or after a fixed number of steps. The positive aspect of this method is that it is easier for the participant to come up with more ideas if they have a red line to follow. The drawbacks are that you miss the spontaneous energy that comes from traditional or full group brainstorming.

In addition to the methods mentioned above, many more methods of brainstorming were described by Miller, in his book on brainstorming [51].

Before conducting any of the above mentioned brainstorming methods, it is really important to go through the basic rules of brainstorming with the participants, and during the process it is important to make sure none of the participants violate these rules. The rules are specified by Miller:

1. **Focus on quantity, not quality** - During the brainstorming round, it is important to gather a lot of ideas. To improve the quality of those ideas is supposed to be done in a latter stage.

2. **Withhold evaluation** - It is important not to critique an idea during the brainstorming round, since this might lead to people not wanting to share bad ideas (which is counterproductive, since quantity is key).

3. **Encourage wild, outlandish ideas** - Simply put, it is easier to tone down a crazy idea, rather than making dull ideas interesting.

4. **Combine or build on ideas from others** - An easy way to get more ideas is to combine two or more ideas into new ideas.

The expected results from all brainstorming methods are ideas. How many ideas depend heavily on the number of participants, their mood, the time given to them and the methods used.

4.1.4 Participatory Design and Brainstorming

When developing new technology it is important to adapt the technology to the user, not to have the user adapt to the technology. One prime way to achieve this is by involving the potential users early in the process of designing the technology. This is an aspect

of participatory design [52] and revolves around having the thought user group assist in coming up with the technology. This is most often done in the ideation and conceptualization stages of production, especially if the majority of the developers working on a technology is not the intended end user. Exploratory Design Games [53] is one interesting approach to participatory design.

4.2 Concept Evaluation

Ideas that are generated have to be filtered, ranked or improved in order to finally pick what ideas to proceed with. Several methods exist for evaluating the ideas that are found during the ideation phase of a project:

1. **Investing in ideas** - Taken from Miller's book on brainstorming, this method revolves around having the participants spend makeshift currency on the ideas they think are the best. The idea with the most currency invested into it is then deemed the best idea. The upsides with this method is that it is intuitive, and that participants can individually rank the ideas while still producing a collaborative end result. The drawback is that it might seem a bit childish to some participants.

2. **Pros and cons** - This method, also taken from Miller's book, is designed for participants to rank the ideas based on pros and cons separately. The goal is to rank the cards from strongest to weakest while not revealing what specific ideas the pros and cons are connected to. When done, the cards are flipped over and the results are revealed. The method helps participants see the benefits and risks of every option, but it has some drawbacks, one being that the participants may remember what card they liked and vouch for that regardless.

3. **Cost vs. benefit matrix** - This method was taken from a Power-point presentation by Health Quality Ontario [54]. The benefit cost matrix aims to rank every option against each other on two axis - namely cost and benefit. After all options are placed into the matrix, the ones with the lowest cost and highest benefit are selected. In some cases, the cost is most important, when time is short for example. Sometimes however, cost matters little, and then it is appropriate to select ideas with higher cost, if they have higher benefits. It changes on a case by case basis and is something that needs to be discussed afterwards. A positive aspect of this method is that it results in a graphical overview of how the ideas relate to one another. The cons with this method is that it might be hard to place ideas into the matrix at the correct points, or that it might be hard to pick an idea in the end anyway.

4.3 Concept Creation

One useful method for creating a concept is to define what is called an MVP. One way to do so is to filter out a set of critical features that need to be implemented in order to realize the fundamentals of the concept. Based on the result of the previously mentioned value-cost matrix the following categories can be derived. Each category loosely represents one area of the matrix. This idea of creating feature categories from the matrix is our own invention.

Critical features - Without these features, the game will not be playable. They are critical to the application and constitute the requirements for the MVP. These features will be implemented first, and the category will not be relevant after the MVP has been developed. This category does not only contain game features, since it also consists of tasks for programming the technical foundation of the game.

Important features (Highest benefit, high-low cost) - These features are important for the application in order to make it enjoyable, however, they are not crucial, which means that the application will still work even if they are not present. Important features have the highest priority when deciding what to implement in each iteration.

Desired features (High-medium benefit, medium-low cost) - These are features that are considered to have high value, but that do not belong in the important features category. High priority, additional content, will be of this feature type, and may be considered as the "cherry on top". The application will be fully playable and, hopefully, enjoyable even without these features.

Additional features (Low benefit, high-medium cost) - Features that will only be implemented if there is extra time. While not considered bad ideas, these features have been determined to have little to no impact on the playability or enjoyability of the application.

Minor features (Any benefit, low cost) - Features in this category are considered to be quick and relatively easy to implement. The overall application will not be heavily impacted if some of these are implemented. However, they are considered to be clear improvements to the game. Furthermore, a number of smaller features might lead to a greater user experience overall.

Discarded features (Lowest benefit or highest cost) - These are rejected features. They have been determined to not be implemented, either due to them being considered bad ideas or because they have a very low benefit-cost ratio.

4.4 MVP Development and Vertical Slicing

To define an MVP is a good way to establish the first goal of the project. In this thesis an MVP is defined as:

> A product, featuring the least amount of features, while still being runnable and qualify as an AR game.

Product-wise and implementation-wise, this MVP is the worst acceptable result of the thesis. A vertical slice, on the other hand, is a more refined version of a product which aims to accurately represent an eventual final product. A vertical slice in this thesis is defined as:

> A refined product, which contains a set of features which makes it qualify as releaseable, and which accurately represents the potential final application.

Vertical slicing is a concept derived from agile principles, and is described by Ratner & Harvey [55]. While not a method per say, defining a vertical slice is a solid way of establishing a long-term goal which transcends the short-term goals of each development iteration, which aids in keeping the tasks of each iteration relevant to the goals of a project.

4.5 The Agile Development Process

One of the most common software production approached is the utilization of Agile development methodology. Agile development is a group of applied software development methods that originates from the Lean manufacturing methods [56]. There are a lot of different frameworks for Agile development, such as Extreme programming, Kanban and SCRUM. Arguably, the simplest of the agile development methods is SCRUM, since SCRUM is designed with small teams in mind. It is to be noted, however, that SCRUM contains a plethora of methods, which means that not all of them have to be utilized [57].

In SCRUM, there are three different roles that are assigned to various team members, each with its own responsibilities. There is the product owner, who is the person owning the project or product that the team or company is trying to make. The next role is the Scrum Master. The responsibilities of the Scrum Master is to guide and coach the team to achieve the desired result in the desired time frame. This person is also the one managing the daily meetings, and he or she is also the one who mainly communicates with the product owner. The final role is the Team member. The team member is simply part of the team that is trying to finish the project under the SCRUM Master's guidance.

A central concept of SCRUM is fix length iterations that repeat [57]. Sprints are usually

between one and four weeks long, but shorter sprints are preferable. Another important concept of SCRUM is to have a sprint meeting once per sprint (either in the end of a sprint, or at the start of a sprint). During the sprint meeting, the SCRUM Master reviews what has been done the previous sprint and the desired results of the upcoming sprint are discussed. The third important aspect is daily meetings. This is to prepare the team for the day and make sure that everyone are always sure of what they are supposed to work on. The daily meeting is traditionally also held by the SCRUM Master. The final core concept of SCRUM is the SCRUM Board. A SCRUM board consists of cards that represent different tasks. Depending on their position in the production chain, they are placed in certain areas on the SCRUM board. This board is in place mainly to grant the team, as well as the SCRUM Master and product owner a clear visual representation of how far the project has progressed, and if anyone is stuck and needs help.

The agile cycle for SCRUM is composed of four steps, and repeats once every sprint:

- Test the latest changes made in the previous sprint
- Evaluate changes made in the previous sprint and the application as a whole
- Establish new requirements based on the prior evaluation
- Implement or modify features as suggested by the new requirements

4.5.1 Result Evaluation

Conducting interviews Cote & Raz give some advice on how to recruit participants for interviews related to game research [48]. They argue that game research is relatively easy to conduct, since most games have a well-defined community organized on specific forums on the internet, which makes the target audience easy to find. However, they also warn that most people who are active on forums do not necessarily represent the average gamer, since they are more likely part of a minority of highly dedicated fans of a specific game. Once interview participants are found, there are a number of ways in which interviews may be conducted; ranging from structured questionnaires to more open discussions. What interview method to use depends on the needs of the project, which means that it is important to establish what information is sought out prior to planning the interview sessions.

TLX forms Nasa TLX forms [58] is a useful tool when evaluating a user's perception of a certain feature. Unlike interviews, Nasa TLX forms result in quantitative data which measure a tester's experience while performing a given task. These forms could potentially be used in order to compare different features of a game with one another, or even to similar features in other games.

The fly-on-the-wall principles One way of conducting evaluation during the iterative

process is to meet with the testers and observe them as they play the game. This is known as the fly-on-the-wall principle [59]. If the AR setting causes issues in conducting such testing, the players could be observed in a manner that resembles the approach of Serholt & Barendregt [47], in which specific interactions between the virtual entity and the players is observed and recorded. Emotional expressions and body language are examples of events to monitor which could be used in order to measure how emotionally engaged the players are while playing the game.

4.5.2 Forming New Requirements

During the sprint meeting, either at the end of a sprint or at the beginning of one, the new requirements or tasks of the next sprint are set. There are a number of approaches to decide on what features should be brought into the next sprint. For example, instead of selecting a number of features for each sprint, as one would normally do, one overarching concept can be selected instead. Exactly how the system is to be implemented is then decided throughout the sprint, in a manner that resembles rapid prototyping [60]. In any case, it is important to evaluate the product beforehand and take the evaluation findings into account when planning the next sprint. Evaluation data in this case does not need to be directly gained from external testers, but could also consist of bug reports formulated by the developers themselves.

When estimating how much time a selected feature requires, several different methods can be utilized. One of them is planning poker [61], with which the team ranks the tasks in terms of time cost, by using cards that have values in a Fibonacci series of numbers. Each task is brought up, and the team members then play a cost card, estimating how much time they estimate the task requires. If someone ranks the card abnormally high or abnormally low, he or she has to motivate their decision. After discussing the matter, the group either agrees on how long the task takes, or the mean of the selected numbers is selected.

4.5.3 Implementation

After new requirements have been established, it is time to implement them. This marks the beginning of a new iteration cycle.

During the sprints a SCRUM board is used. The exact structure of a SCRUM board, however, is free to vary, and it can be either physical or digital. The physical SCRUM board is probably preferable if the whole team is located in the same physical place. Otherwise, an electronic scrum board may be used. There are many sites online that provide this type of service. One such is the website Trello [62], which provides a free, easy to use online SCRUM board.

4.5.4 Iteration Stop

When the planned time for the iterative phase comes to an end, the loop is halted and development is considered done. The reason for choosing an approximate stop date for the iteration phase is that the product is improved with each cycle, and thus more iterations equal a better product. The goal is therefore to conclude as many sprints as possible in a given time frame, rather than setting the total number of finished sprints.

4.6 Interview Data Analysis

In an article by Cote & Raz [48], it is described how you would analyze and interpret data gained from interviews. Before the analysis of the data can commence, however, the data has to be transcribed. A question to be answered is at what level to put the transcribing, but it is relatively straightforward, since the concepts of the game are well known. After the data is transcribed, Cote & Raz continue to explain the analysis process. Mainly the task consists of breaking down the data into patterns and putting those patterns into a theoretical framework in order to draw conclusions. When designing the interviews, considerations will be made regarding how to best extract data that is related to the goals of the interview, namely the entertainment value of the game.

4.7 Ethical Considerations

When developing AR games featuring GPS map integration, a long line of concerns arise. Some of them are connected directly to the users and their well being, other concerns revolve around their personal information and integrity, and lastly, there could be concerns regarding such technology's impact on society as a whole.

One concern is that virtual companions, in the not-to-distant future, could gain the ability gather highly personal data about users, in order to respond to said users more effectively, and this type of data is considered to be highly sensitive [63]. As long as the project does not conflict with GDPR, it will not give rise to any issues, at least from a legal perspective. In any case, the pet featured in Augotchi was never planned to have an advanced AI that could, for example, analyze, encode and store data which represents the feelings of its owner.

AR applications could also have questionable impacts on society. Miguel Sicart expresses one such concern, namely the implications that AR applications have in regards to commercial rules and legislation in public spaces [64]. He argues:

> "GO is a connected network of corporate interests, from the Pokémon Company to google and fast-food companies that have discovered that in AR, public space regulations are not necessarily applicable. Public space is threatened

by an interface that is proprietary, and by the lack of regulations and codes of practice." [64]

This is certainly something that will have to be kept in mind when developing any kind of AR application. But as of now, no such codes of practise exist.

One of the most important ethical issues of the Augotchi project is the immediate danger connected with playing AR games like Pokémon GO. This is illustrated by the Pokémon GO application itself, which has warnings that are put in place to remind the player of these dangers. When starting the application, while the game is loading, the following text appears:

"Remember to be alert at all times. Stay aware of your surroundings."

Furthermore, every time the game is loaded and opened, a popup is displayed with an "OK"-button and one randomly selected warning, see the central image of figure 2 below. Warnings include texts such as:

"Do not trespass while playing Pokémon GO."

There are also conditional warnings implemented in Pokémon GO. For example, when the player is moving too fast, obtrusive warnings pop up that remind the player of not driving and playing the game simultaneously.

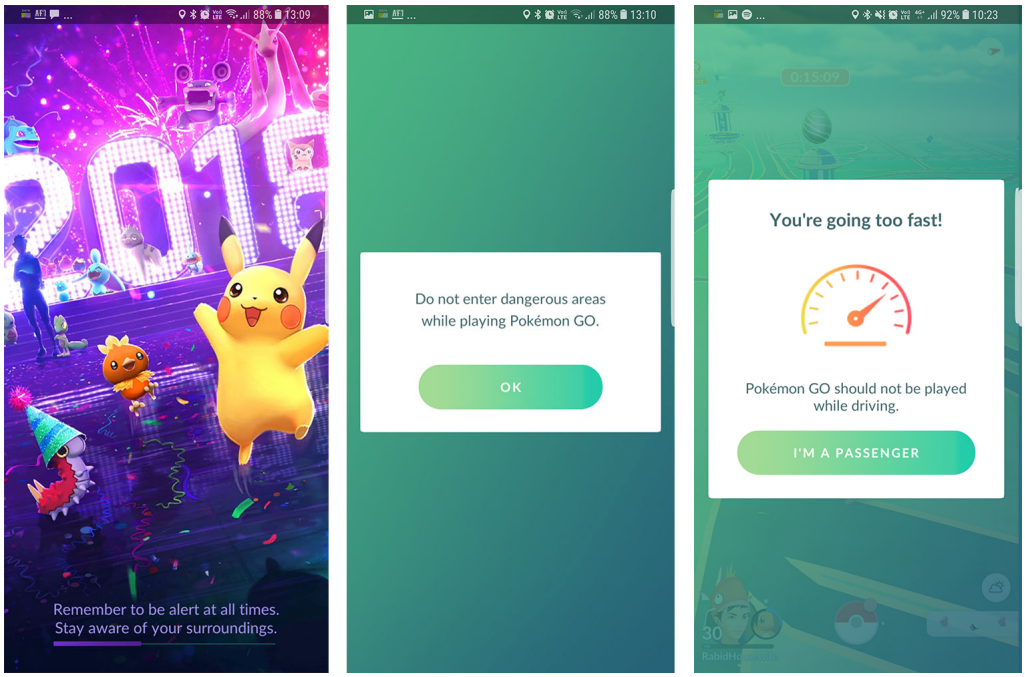


Figure 2: Player warnings in Pokémon GO

These warnings illustrate the concerns that the developers have regarding how people play their game, all of which are related to the players physically moving around in

public areas. Hence, these are ethical issues specifically relevant to AR games that do not arise when playing games, sitting down, in the comforts of one's home.

For Augotchi specifically, it will be important to emphasize these dangers when bringing in testers. When bringing in testers, these have either come from communities of people who are accustomed to the dangers of AR, or they have been people that the team has met and informed in person. Hence, obtrusive popups throughout the game will not be necessary, as long as the participants have been properly informed, or have previous experiences with similar games. If a feature of Augotchi differs from similar games in a way that could make it more risky, this will have to be conveyed to the testing participants. An example of such a difference would he how the game's content is placed in the world.

5 Planning

In order to reach the goals of Augotchi, this project is divided into a number of phases. These phases are the conceptualization phase, the MVP development phase, the iterative development process, and finally, the evaluation phase.

5.1 Conceptualization

The primary goal of the conceptualization phase is to formulate a list of critical features and/or requirements that will be carried forward to the MVP development phase. This phase is also planned to explore the possibilities of AR games and virtual pets in general. Hence, ideation is the core of this phase, which consists of various brainstorming activities and idea evaluation techniques. A co-design workshop with external participants will be conducted in order to produce a wider array of ideas.

5.2 MVP-development

During the MVP development, the first version of Augotchi is planned to be developed. The features that were selected from the previous conceptualization phase will be ranked according to the ranking system discussed in section 4.3, and then implemented. The MVP-development phase of the project is essentially what is called the "initial phase" of SCRUM, which aims to provide a solid foundation for the future iterative process.

5.3 Iterative development

The iterative development phase will consist of a number of sub-phases, divided into iterative cycles known as sprints. These phases are the planning, implementation, testing and evaluation phases. During the later iterative phases, when testers have been recruited, evaluation will be conducted in order to evaluate the changes made during each sprint. The results of the evaluation are then used in order to plan and execute the next sprint. The goal of each sprint is simply to improve the prototype and to gather data which may lead to insights regarding the development of a game like Augotchi.

5.4 Evaluation

During the evaluation phase, the testers will be interviewed in order to evaluate the prototype as a whole. Data gathered through evaluation sessions during the iterative process, as well as the data from these interviews, will then be analyzed in order to draw

conclusions regarding the development of a game which aims to emotionally engage its players through a virtual pet.

6 Process and Execution

6.1 Preparation and Research

The preparation phase of the project included a number of steps, including a literature study, constructing a time plan, as well as exploration of available technology and possible methodology. A formal analysis of game play was also conducted, which was presented in section 2.4

6.1.1 Establishing Roles

Prior to the thesis work taking place, the skill sets and goals of us, the students, were identified in order to plan a thesis that would be well executed in a manner which would satisfy both parties. While we both had a background in computer science engineering, our ambitions and interests varied. Kevin worked as a 3D environment artist for Far North Entertainment, and Simon mainly as a game designer and developer.

This difference has been important when planning every phase of the project, and a major part of the iteration planning consisted of balancing the division of labor, so that both students had an approximately equal workload even though the tasks were of entirely different natures. During the prototype development, this division has primarily been between programming and graphic assets creation/design. These role differences have also been utilized during theory research, to make sure that each topic was studied by the person for whom it was most relevant. Whenever the workload turned out to be uneven during an iteration, the freed up student worked on tasks belonging to a shared pool of tasks, such as UI creation and planning.

6.1.2 Theory

With both students having little knowledge regarding emotional engagement and relationship forming between digital artifacts and people, a literature study was conducted in order to gain a better understanding of said topics. The supervisor of the project supplied us with some video material and articles that could be relevant, which was a good starting point for the study. We split the material in two and studied the contents respectively. The knowledge gained was then shared between the two of us in a small literature seminar.

The main problem with most of the videos and articles were that they all discussed contexts in which the digital artifacts were useful to someone in some sense. Most of the studied videos and literature focused on how to improve certain aspects of human life, such as elderly care, or the education of children. Augotchi was meant to be a game,

hence a product supposed to entertain, which made it hard to find other projects with the same direct goal in mind. The literature which revolved around digital characters in games and other entertainment media was helpful for the design of the game and its character, but did not connect the digital character design to the deeper emotional engagement that Augotchi would hopefully lead to. Similarly, when studying some of the literature directly referencing the Tamagotchi, it was established that there were clearly strong bonds forming between the digital pet and its owner, but nothing was established about why this was the case.

The studied literature was divided into different areas of research and presented in the theory chapter with these areas as section titles. Each section could vaguely be described as answering a specific question:

- AR - Benefits and Problems - What are some general considerations when working with AR applications?
- Emotional Engagement in Entertainment Media - Why do people care about physically unreachable characters?
- Relationships with Virtual Companions - What has already been studied regarding relationships between people and virtual companions?
- Virtual Creature Graphical Design - How should a creature's looks and behaviour be designed in order to make it effective at creating such relationships with the user/player?

The goal of the thesis, following the literature study, became to design a virtual pet in a game that would adhere to the findings of the studied literature, and then test if emotional engagement of the player could be achieved. This is the missing link that the thesis first aimed to answer. However, due to reasons described later in sections 6.7.4, 6.7.6 and 6.7.8, the focus question was changed to revolve around the design of a virtual companion in the specific AR setting.

6.2 Utilized Technology

Before developing the software prototype, it was deemed important to explore what features and tools could be gained from already existing solutions on the market. By using Google, forums and the Unity asset store [65], tools and solutions to most technical challenges would be found, evaluated and tested, in that order. The process of finding a solution to a specific problem was divided into 5 steps:

1. Establish what needs to be solved.
2. Find solutions to the problem.

3. Evaluate the solutions by looking at descriptions, user reviews, price and examples of where the solution has been used before.

4. Compare all solutions and rank them based on the needs of the project.

5. Test the highest ranking solution in Unity, declare whether it is viable or not. If it is not viable, remove it from the list and repeat this step for the next item in the list.

6.2.1 Platform

When deciding which platform to use for Augotchi, the main criterion was its potential for AR functionality. The number of device types that were deemed suitable in this regard was small, not necessarily because the excluded platforms could not do AR at all, but because of the fact that the good options outmatched the less optimal ones. A desktop PC, for example, is heavy, unportable and does not usually come with GPS integration or even a camera built in. On the other side of the spectrum, there is the Microsoft Hololens, which is a headset-like device specifically developed with AR in mind [66]. There are various alternatives to the Hololens as well [67]. However, none of these AR devices are, even remotely, in a price range that would fit the budget of the project. A platform that is more available had to be found, and the smartphone was therefore the de facto solution for Augotchi, a choice for which there has been little concern.

The smartphone, as an AR device, has a number of strengths, as described in section 2.2. In addition to the technological capabilities of the device itself, it also opened up possibilities during user testing, since a majority of people in Sweden already own such a device. The availability of the platform is also important from a commercial standpoint. Furthermore, both of us have previous experience in developing for Android, and own Android phones, both reasons for developing for Android specifically. The phones that were used during the development were a Samsung Galaxy s5 [68] and a Samsung Galaxy s8+ [69]. These devices are three years apart in terms of technological advancement, which is useful when developing an application that will, preferably, work on a wide variety of devices.

6.2.2 Software Solutions

Before heading into the initial design phase of the project, it was deemed important to have a good grasp of what is possible and not in technical terms. In order to not create a concept that would be hard to realize within the time frame of the project, a variety of available software solutions were researched, and a set of applications and APIs [70] were selected as the foundation for Augotchi. This improved the odds of correctly predicting the time that the prototype would take to develop, hence improving the workflow and the chance of the project being a success as a whole. Testing the different components

individually prior to the prototype development also minimized the risk of delays due to technical issues.

Game Engine
A game engine was required for the prototype to be finished within a reasonable time frame. It provided that which is required in any game, such as rendering graphics, handling input, playing sounds and managing all the objects within the game. The two game engines that were considered for the development were Unity and Unreal Engine. Both would be free to use throughout the project and they are, arguably, the most popular public game engines of small and big game development companies alike [71].

The game engine that was chosen for developing the Augotchi prototype was Unity [72]. Our previous work experience was one of the reasons for choosing Unity over its contender, Unreal Engine [73]. The development within the engine would mainly be performed by an experienced Unity developer, which made Unity an obvious choice, since development time is sparse and learning a new game engine takes time and effort. Furthermore, no critical reasons were found that pointed to Unreal Engine being preferable to Unity, even when experience is not taken into account. This is due to the fact that Unity does what is required, and seems to do it well:

- It has build support for a multitude of platforms, including Android, but also iOS.
- It comes with Vuforia built in, a powerful API for AR camera functionality, which has been utilized by a number of famous companies, such as LEGO, Disney and Mercedes Benz [74]. Vuforia is further described in section 6.2.2.
- Mapbox has developed an external API for Unity for dynamically loading map tiles and integrating GPS positioning [75]. This API was tested and verified to work prior to developing the MVP. Mapbox is also further described in section 6.2.2.
- Unity features an asset store with a substantial amount of APIs and graphical assets, some of which are free [65].

This solid foundation of ready-made solutions allowed for the work to be more focused on the content and elements of the game, rather than solving complex technical issues. In other words, it allowed for more time to be spent on the actual thesis.

Fundamental AR APIs
Some of the researched features were of higher priority than others. If Augotchi was to be an AR game, it had to have AR capabilities. The features required were assumed to be highly complex, hence, not feasible to develop from scratch. Therefore, solutions had to be found that provided the desired functionality, for free.

Rendering in the Camera View
This potential feature of the application is perhaps the one most connected to the concept of AR, and it could be supplied by Vuforia, which is an API for rendering 3D models

within the camera view. It features a number of different rendering targets, including images, cylinders, QR code-like images [76], called VUmarks and more. Unity had recently partnered with Vuforia when the thesis begun, and had built-in support for its API, which would make it highly stable and comparatively easy to work with. Vuforia could potentially bring one of the most important functionalities to Augotchi, as rendering the virtual creatures in the camera view could possibly be a critical feature of the prototype. However, Vuforia and its camera integration was never used. This was due to the limitations it came with. Only a handful of devices were supported by Vuforia at the time, and it was deemed counterproductive to substantially reduce the potential tester base.

Vuforia was not the only solution to the camera rendering, however. There were alternatives as well, such as CraftAR by catchoom [77] and Google's ARCore API [78]. Similar to Vuforia, ARCore had a significant disadvantage, as it was very young and only supported an even more limited number of devices, none of which were available during development.

Dynamic Maps & GPS Positioning
This is the core mechanic of Niantic's games Pokémon GO and Ingress, which allows the real world to become the environment in which the game takes place. In Niantic's games, real world landmarks, often with cultural significance, act as markers on the map. In order to perform actions in the game, the player must physically visit these landmarks in order to interact with their respective markers within the application. Curiopets also uses a similar system. It would be preferable to have such functionality available for the Augotchi prototype.

There were a number of solutions that claimed to provide this functionality. However, most of these solutions either had an upfront cost, without any means of trying it out before purchase, or they simply did not suffice for what was planned for Augotchi. One promising API was Tangram Unity, which at a first glance seemed to solve the problem. However, when tested in Unity, it was concluded that it did not come with a ready-to-use GPS positioning system, and that the pricing would be far too high, even for a small prototype [79].

The solution that was the most promising was Mapbox, an API that came with a fully functional Pokémon GO-like map system [75]. It is capable of dynamically loading vector map tiles and can position the device in the map by using GPS coordinates. This API was first tested and verified to work on the Samsung devices used by the team, at least somewhat well. While not perfect, it was decided to be the best available solution. It also had a generous pricing policy, which allowed thousands of monthly active users for free. If Mapbox turned out to not be suitable for Augotchi, a custom system would have to be implemented using, for example, Google's Static Map API for Unity [80].

Secondary & Peripheral Solutions
This section briefly describes some additional ready-to-use solutions for functionalities that were desired for the Augotchi prototype.

Speech Recognition
It could be interesting to utilize voice commands in Augotchi as a means of communicating with the virtual creatures of the game. But it turned out to be an unsupported feature in Unity, which meant an external API or plugin had to be used. The asset store had a number of priced solutions for speech recognition. Google Cloud Speech Recognition claimed to be a cross-platform speech recognition tool and it had good reviews [81]. However, there was no way to test it before purchase. Nevertheless, if speech recognition turned out to be a desired feature, it would be the solution to try first.

Step & Distance Counter
Keeping track of distance travelled and number of steps taken is a feature which could be useful, not only for gameplay mechanics, but as a tool for collecting quantitative user data during testing. It makes it possible to measure the effort put in by the user while playing the game, and also makes it possible to see how much the map integration is actually being used. Pedometer API was free and lightweight, which made it ideal for the Augotchi prototype [82].

Push Notifications
Being able to send messages to the user while the application is in the background, or even messaging them when the application is closed, could be valuable for both the gameplay and the testing of the application. This is another feature not directly supported in Unity. Local notifications are supplied by a free Asset Store asset, called Simple Android Notifications Free, which also had a paid version with extra functionality [83]. This solution only provided local notifications, however, and would not be used for sending messages to the user when the application was closed. Remote push notifications could be researched further if an explicit need to use them was encountered during development.

6.2.3 Media Creation

During the project, many types of software would be used, in order to create assets of varying types. This section will present the software that was used for creating the visuals and sounds of the project. When looking at the graphics creation, there were two main types of assets, 3D and 2D. Since 3D and 2D assets were made separately in different applications, they will be described individually. Sound effects and music applications are also briefly described.

3D Graphics
Regarding the in-game assets, a decision to use 3D models or 2D sprites had to be made. In the end, 3D models were chosen as the main graphic type. The reasoning for this was mainly that 3D models support AR in an elegant way, allowing the user to view the objects from different angles. Another important factor for choosing 3D was the experience of the developers, meaning that high quality 3D assets would take a comparably low time to produce.

After choosing 3D as the main perspective, tools for developing said 3D graphics had to be chosen. The applications that people in the industry mainly use are Maya, 3D Studio Max and Blender [84, 85, 86]. The software used by larger companies would most often be a paid professional program like Maya or 3D Studio Max, depending on the type of assets required, while Blender is more often used by smaller developers looking for a free, yet competent, tool. Maya and 3D Studio Max are the most powerful, but the decision to use Blender for the development of the graphics was still reached. There were several reasons for this. They are all highly capable applications. One of the main reasons for choosing Blender is the experience the team already possess with the software, reducing time spent on learning the application. Furthermore, out of the three, only Blender was offering the full software for free. The final reason was that there was no specific reason not to use Blender. It had all the tools needed for the entirety of the development cycle, from modeling to UV-mapping, rigging and finally animating.

After researching the concept of the "uncanny-valley" in 3D rendered virtual animals, it was also concluded that the shading that would be used in the application would be of cel-shading nature, with the addition of an outline-shader (bundled commonly known as toon-shading) [45]. For more information about this, see section 3.4. To assist with the cel-shading, a free asset from the Unity asset store was used [87]. The reasoning behind this was simply to reduce the development time of developing shader-technology, allowing for more in depth development of other areas of the application. The shader was modified, however, in order to fit the specific needs of the pet creation. The changes made are described in section 6.6.2.

2D Graphics

Every 3D model also needs several 2D image components. These 2D images, bundled together with a set of parameters, are called materials, and are what determine how the model looks in 3D space. The most basic of these images, or maps, is called the diffuse-color-map, also commonly known as the texture. To make these textures, a 2D picture editing software was needed. Examples of this type of software is Adobe Photoshop, Paint, Gimp and Adobe Illustrator [88, 89, 90, 91]. The decision was made to utilize Far North Entertainment's Photoshop license, mainly because Photoshop is the most powerful tool, which gave the team a high level of flexibility in what needed to be created, a flexibility that none of the alternatives could compete with. Additionally, the developers had extensive experience with the software, making the learning process close to non-existent. To increase the graphical quality, normal-maps would be used in addition to diffuse-color-maps. Normal-maps are incredibly hard to make by hand, and is most often made through baking the map in a 3D program. This being said, a simpler alternative would be utilized for the project, namely an internet site called "normal-map online" [92]. This site converts a texture, called a heightmap, into normal-maps as well as several other map types that could be useful (including specular-, displacement-, and ambient-occlusion-maps) to further increase graphic quality.

In order to turn all of these components into a material that can be applied to a 3D model, some additional software is needed. Usually, the 3D modeling program comes

with a built-in version of this material editor, Blender being no exception. However, while Blender has a built in material editor, the desire to try alternative software arose, namely Substance Designer [93]. The reason why this software was brought up was that Substance Designer might be able to produce a severely better result over that of Blender's material editor, resulting in a better overall graphical quality. In the end Substance Designer was used sparsely, since highly complex textures would not necessarily increase the quality of the game's look.

In addition to what is seen in the game as content, more 2D imagery for menus and the UI had to be created. The earlier mentioned Photoshop license for making 2D images would also to be used in order to make the assets for the UI.

Sound Effects & Music
Sound is a component in most games, and Augotchi would be no exception. For this purpose, Audacity [94] was used in order to record and create sound effects, while FL Studio [95] was planned to be used in order to compose eventual music. Audacity is a free audio clip editor, and FL Studio is a powerful tool for creating music, for which one of the team members possesses a license. Not a lot of consideration was made regarding these choices, as the sound of the game was regarded as not as important as most of the other components of the game.

6.3 Methodology Research

The methods used during the project has been acquired in a variety of ways. For the most part, there has been an initial idea of how to perform certain activities, and this initial idea has then been expanded upon by further research.

The methods used during the conceptualization phase were broadly defined early on, with prior experiences from studies at the master programme as the foundation. Some form of brainstorming co-design workshop would be planned, and an analysis of similar game concepts would be performed. The details of exactly how to execute the activities were then gained from literature.

Similarly, the development phase was determined to feature an agile process, featuring an iterative development process, that would fit well with the goals of the project. However, a reversed approach was adopted, where the methodology was first studied, and the details established based on prior experiences we have and the goals of the project, resulting in a SCRUM-like approach which would be flexible and allow for radical changes in planning. The reason behind this was that the estimated time required for the prototype development could not be determined, as many factors regarding development time were unknown, and since the planned user testing was also deemed hard to accurately predict. The goal was to have each iteration span, at most two weeks, and preferably, one week. What methods to use for each individual activity remained undetermined. These would

instead be researched and selected when planning each activity.

The ethical considerations for the project was not deemed to be a major issue, since Augotchi is to be an entertainment product. The ethical considerations mostly regard how the project itself would be performed, rather than the implications of the end results. Some literature was studied, and a couple of similar games were briefly analysed, in order to establish what could go wrong, especially in relation to testers who would be playing the game in potentially dangerous environments, and whose game-related data would be collected. For more information on ethical considerations of the project see section 4.7.

6.4 Quick Surveys

A couple of minimalistic surveys were posted on the Pokémon GO [96] and Ingress Reddit [97] pages. The surveys featured one multiple choice question each, which simply asked the respondents to pick the features and general themes that they liked most about the respective game. These surveys were posted with two goals in mind. The first goal was to get an indication of what people liked most about the games, and what features were less important to them. The second goal was to see what the response would be, in order to better evaluate responses to future posts regarding tester recruitment and possible additional surveys. The gathered data was later converted into a diagram and shared with the respondents on the forums.

The surveys were constructed using Google forms. The following is the short description that was posted with the quick surveys:

> *Greetings!*
>
> *We are two master students from Chalmers University of Technology, Gothenburg, Sweden. We are, at the moment, developing an AR game as part of a master thesis project. This survey is meant to give us some answers to why people like to play Ingress, and our hope is that those answers will help us in the development of our game.*
>
> *DISCLAIMER: Note that we are not affiliated with Niantic Inc in any way. The answers might be presented in the final master thesis report, and they will potentially be used in order to develop a commercial product sometime in the future. If you do not want your answers to contribute to any of these causes, please do not respond.*
>
> *We appreciate your help! Thanks!*
> *Simon & Kevin*

The data from the quick surveys are presented below, starting with the Pokémon GO survey, which was posted on the Pokémon GO subreddit, and got a total of 1490 answers.

Most liked feature	Number of responses
Working towards filling the Pokédex	1106
Finding rare Pokémon	1089
Walking around/Exploration	788
Collecting the strongest Pokémon	758
Raid battles	457
Socializing	392
Gym battling	306
Overall atmosphere	285
Other	91

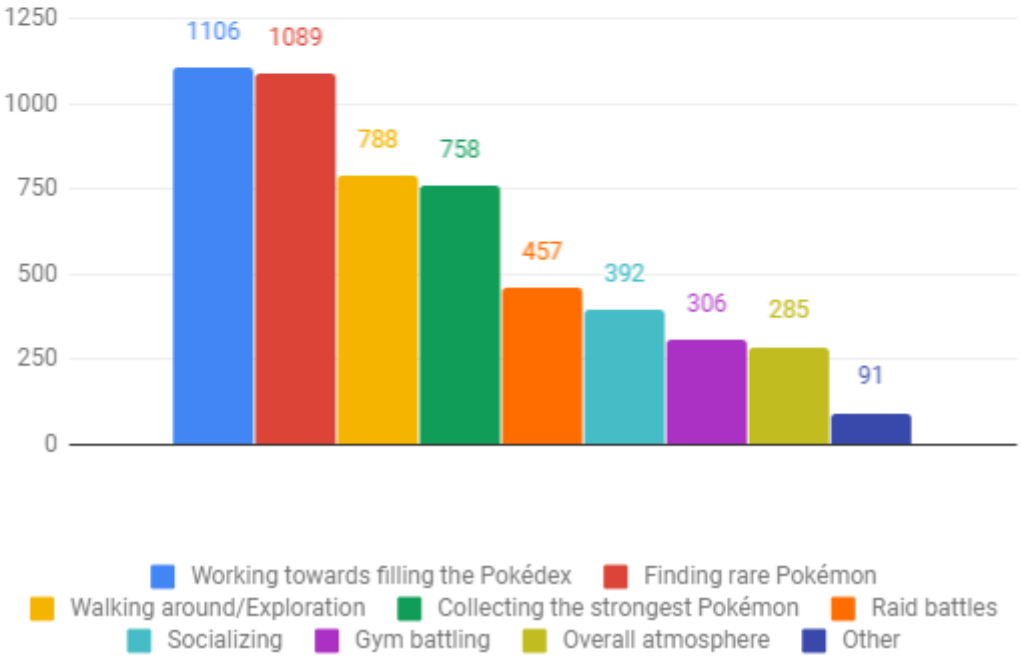


Figure 3: Summary of the Pokémon GO quick-survey responses.

Following are the answers from the Ingress survey, posted on the Ingress subreddit, which got a total of 996 answers. This survey got less answers, but the percentage of people

of the community that answered was considerably larger. Reddit stated that 34735 people were active on the subreddit, suggesting that almost 3% of people who were active answered the poll (compared to the 0.16% people who answered the Pokémon GO poll).

Most liked feature	Number of responses
Walking around/Exploration	708
Building Portals/Links/Fields	626
Destroying enemy Portals/Links/Fields	532
Collaborative Operations	438
Socializing	406
Hacking/Gathering items	348
Meeting new agents	298
Events	281
Overall atmosphere	222
Other	76

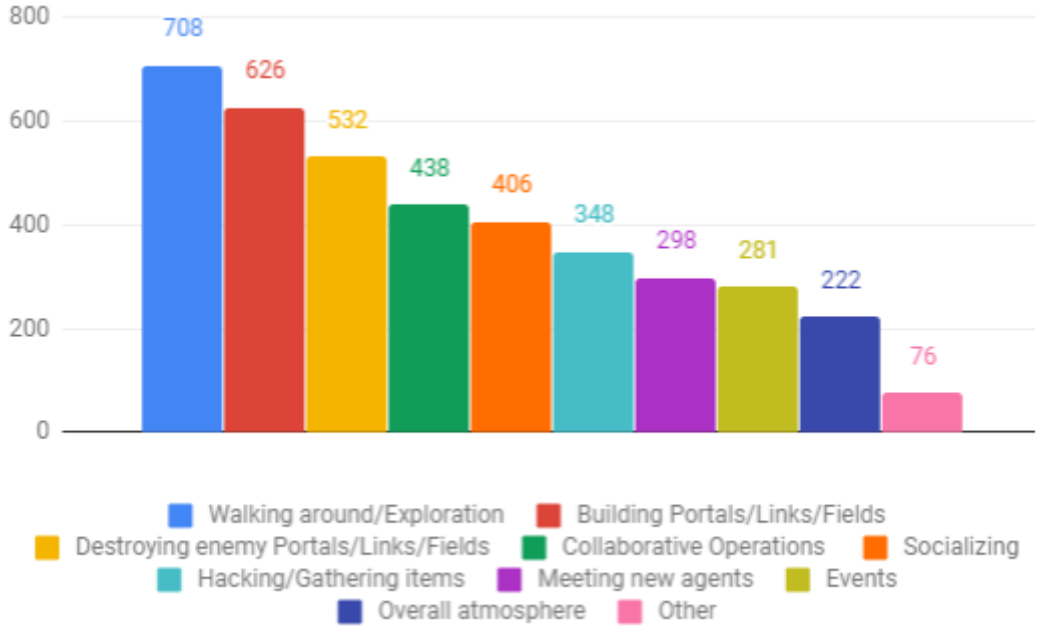


Figure 4: Summary of the Ingress quick-survey responses.

The other category had some highlights regarding features which we had not included in the list of possible answers. A couple of such answers for Ingress were contributing to the game by creating new portals, as well as following the narrative and story of the game.

For Pokémon GO, hatching eggs (gaining pokémon by walking long distances) and shiny hunting (finding and catching special rare versions of certain pokémon) were two features that got multiple hits.

The surveys were not intended to give a deep understanding of the game play elements of each game. Rather, it was aimed at giving a clear picture of what made the games appealing to the players in broad terms. The perhaps most important finding is that players of both games enjoy walking around in the real world as part of the game experience. Another finding was that the Pokémon GO players enjoyed collecting things to a much higher degree than taking part in combat. The results from the quick surveys helped guide the development of the fundamental concept of Augotchi. This can be seen in the broader themes featured in the game, such as the real world exploration and collection of items.

6.5 Conceptualization

During the conceptualization phase, the core features of the game were defined. The concept of Augotchi has always had a number of features established from the very start. Some kind of AR functionality, a virtual pet with basic needs, as well as means for the player to satisfy those needs. However, ideas for what to add to the game in addition to the basic features had to be generated and ranked in order to better plan what to implement, and in what order.

Three ideation workshops were carried out, one with the team only, and two in which the brainstorming rounds were performed by external participants, supervised by us. The first workshop was intended to be as practical as possible, where we solely focused on listing what has already been tried in the genre, and it was heavily influenced by the previously conducted formal game analysis. The two later workshops were focused on finding out what others might think would be fun or important in a game like Augotchi.

The first co-design workshop took place during the conceptualization phase. The second workshop took place during the iterative process, and is further described in Section 6.7.5. The results of these workshops are presented in Section 6.5.2 and 6.7.5 respectively.

Before the first co-design workshop, an internal brainstorming workshop was carried out by the team, which was loosely based on the workshops designed for the external participants. The focus questions were tested out in order to see if they could lead to valuable answers. There was also an emphasis on not being too crazy in this internal workshop, since this was the main focus of the co-design workshops. Instead, the aim was to think inside the box and list items that were considered basic mechanics or features, so that nothing fundamental was missed.

6.5.1 Co-Design workshop I

The participants of the co-design workshop were young people, aged between 24-26, that the team knew. Each group session had one female, and three male participants. There was no inherent reasoning behind this group division, as it was simply based on the availability of the participants. Three of Far North Entertainment's employees partook, distributed over both group sessions. This meant that three out of eight participants had experience within the field of game development, but all participants shared an interest in video games to some degree. Participants not part of Far North Entertainment were well informed about the fact that professional game developers took part in the workshop.

The fact that the participants knew the team members was deemed not to be a liability, since the main reason for holding the workshop was to get new fresh ideas from people not concerned with any of the limitations of the project. Hence, the team only led the two sessions, and did not partake actively.

Since the participants were not offered any compensation for their time, the team deemed it important to make them feel like they were taking part in a lucrative and professionally executed activity. Furthermore, the workshop was designed to, first and foremost, be fun. Hence, it was thoroughly planned, and the techniques selected with care, in order to meet the requirement of fun, while still having potential to generate valuable content.

Each group session was expected to last 130 minutes. This time was overshot during the first group session by approximately one hour, which led to the second session being rescheduled. The main reason for this miscalculation was that the discussions that arose within the group were longer and more frequent than previously anticipated. The participants showed that they cared about their answers, and that they did not want to give an answer that was not well thought-out. The second major miscalculation was the time between the brainstorming rounds.

The second group session was executed more smoothly, partly due to the time limit being increased by one hour, but also due to some small changes made to the session planning. To make things more fun for the participants, the sessions were executed quite loosely, giving the participants time to discuss things, plenty of time for breaks, and with an additional twist to all of the brainstorming rounds in order to keep things interesting. This twist was done by tweaking the brainstorming method of each related focus question. The feedback that was received from the first group session was positive overall, so while some changes were made to the planning and logistics of the second session, the brainstorming rounds were not changed in any major way.

The following is a brief summary of the methods utilized, as well as how they were carried out in practise; for more thorough information, see the methodology chapter, Section 4.1.

- **Introduction** - the students presentet themselves, the project and the workshop.

- **First Brainstorming Round** - During the first brainstorming round, a variant of the "stickies" brainstorming method [98] was utilized. This method revolves around the participants writing sticky notes with as many answers to the focus question as they can in the allotted time. The twist of this round was a variant on "mind reader" [98]. Mind reader asks the participants to not answer as themselves, but pretend to be another person, assigned to them through paper-strip lottery. The names on the paper strips were people that were in the room, as well as some famous people. The first group produced some less valuable answers during this round, so the number of extreme personalities was reduced for the second group. Lowering taxes and turning the pet into a wi-fi access point are examples of such answers.

- **Short Break** - The participants were given a five minute break.

- **Second Brainstorming Round** - During the second brainstorming round, the paper swapping brainstorming method [98] was used, which had the participants write what resembles stories on sheets of paper. The first participant wrote an answer to the focus question on the paper, which was then continued by the other participants. The twist of this round was reversed brainstorming, and the participants were asked to answer a reversed version of the focus question. The content generated by the twist part was not useful, but it was a fun activity for everyone involved.

- **Short Break** - The participants were given a five minute break.

- **Third Brainstorming round** - During the third brainstorming round, a variant of the grid brainstorming method [98] was utilized. This method had the participants write on post-it notes, answering the three focus questions. They they picked their two favorite answers, and the host pinned them to the wall in rows and columns. This resulted in a grid-like structure where the post-its intersected with each other in the grid cells (see figure 5 below). The participants who had not written the notes in a particular cell then had to combine the notes into a new idea. The twist used this time was to exaggerate the focus questions, so more extreme results would be achieved.

- **Long Break** - A 30 minute break. The participants were offered coffee and cinnamon buns.

- **First Evaluation Round** - In this round, the results of the previous brainstorming rounds were categorized and grouped by utilizing the quick sort method [99]. After sorting the ideas, the cost-benefit matrix was used, as described in 4.2. The first axis (horizontal) represented the value of the idea in terms of how well it fit the aims of the project. The second axis (vertical) represented which team member would be hit with the heaviest workload (The participants knew the team, and had a good idea of what ideas would result in working time for either team member). The second axis was used mainly for comical effect, rather than actual cost estimation.

Figure 5: Result of the grid brainstorming round.

Once the value of each idea had been established, the team would evaluate the cost of each idea in private.

- **Short Break** - The last 5 minute break.

- **Second Evaluation round** - During this round, a variant of the investing in ideas method, which is described in Section 4.2, was used, with the goal being for the participants to pick their favourite ideas from earlier. The host took the more valuavle half of the ideas from the value axis and spread them across a table. The participants were given different kinds of candy, representing different values, and were then asked to put the candy on top of the ideas. The best ideas were those that had the most valuable candy placed on top of them.

- **Outro and Presentation of Results** - During this round, the results of the day were presented, questions were answered, and the participants were thanked.

As mentioned previously, a number of brainstorming techniques were looked into in order to select a set of techniques that would fit the focus questions. There were three overarching focus questions formulated, one for each brainstorming technique, with corresponding sub-questions for the different phases of the techniques:

- Brainstorming round one: *If your pet could be anything, what attributes would it have?*

- Brainstorming round two: *What activities would you like to perform in order to take care of your pet?*
  - The twist: *If you had to harm your pet, how would you do it?*
- Brainstorming round three had three focus questions:
  - *What would be the ultimate achievement in the game?*
  - *What would be the ultimate item to gift your pet?*
  - *What is the ultimate talent for your pet?*

The questions all relate to the content of the game, in terms of what actions the player can take, what goals the player might achieve, and what the pet should be like.

6.5.2 Results

In the second evaluation round of the co-design workshop, the participants were to invest provided currency in the different ideas. While there were a lot more ideas generated in previous rounds, the second evaluation round finally produced the sought after data. The currency given to each of the participants was distributed as follows:

- 1x 100 value piece
- 2x 50 value pieces
- 2x 20 value pieces
- 3x 10 value pieces

For the first group, the values were distributed as stated above, resulting in a total value of 1080, for the second group it was decided to split up the value tokens some more and give the participants even more different values in order to give them more freedom. The second group's value tokens still resulted in them getting 1080 total points of value.

In the following list, the results from the final round of the first group session are presented. Note that only the top ten results are covered. The assigned value that each idea received is written in parentheses after the name:

1. **Customizable appearance: (200)** This came in at a tied first place with "Randomized Appearance", however, the group decided that they were similar enough to have them as a single point rather than two, and that they did not care much in particular which one of them was implemented. The participants wished their pet to look different from other players' pets.

2. **Gene manipulation: (175)** The participants wanted a way to, over time, shape the pet to be whatever they desired it to be. This could either be done by feeding the pet some substance in order to alter it, or by breeding the pet and get new results over generations.

3. **Smart: (175)** The pet should seem smart. It should at least seem like it has intentions, feelings, and that it did things deliberately. To make something truly smart, so that it actually formed thoughts and intents, were way out of the scope of this project. However, a simple AI could be implemented that at least gave the impression that the pet was making decisions and acting the way, say, a cat acts in real life.

4. **Health: (100)** Health would be important in Augotchi, both for the pet and the player. One of the top answers of the quick surveys the exercise aspect of AR games, which is reflected in this idea. As mentioned, it should be important for both the user and for the pet, so taking walks together with your pet to promote health for both parties would be beneficial.

5. **Speech & Languages: (75)** The pet should be able to communicate with the player and with other users' pets. To have the pet talk to the player by using speech was, however, considered weird, since this would probably lead to problems related to the uncanny valley (see Section 3.4), and this had to be avoided. However, as in real life, pets communicate to their keepers in other ways, and the same principle could be implemented for Augotchi.

6. **Cute: (60)** Human beings tend to care more for cute animals, and thus the group found it important that the pet that was developed would be perceived as cute.

7. **Loyal: (50)** The pet should be loyal to its keeper. This would, for example, hinder the pet from running away, or biting its keeper.

8. **Tacit <3 (50)** The word "tacit", followed by an emoji heart, simply implies that there should be a tacit bond of love between the pet and the keeper, something that often arise in such relationships in real life.

9. **Bring along (50)** The pet should be brought along wherever the user goes, something that is a relevant feature in an AR game like Augotchi. This includes taking the pet on walks and bringing the pet with you when you travel to different countries. No matter the location, the pet should always be with the player.

10. **Random fun (45)** Sometimes, at random, the pet should do something cute or funny to get the user to chuckle. This is also something that pets in real life do.

When calculating the points on the list, the total value does not amount to 1080. As already mentioned, only the items of the highest value will be presented. What could also be deduced by looking at the ideas in this list is that several of them are related to

making the pet more lifelike, and to make it behave in a desirable way, much like a real pet would.

Figure 6: The setup for participants investing "currency" in the various ideas

Next, the results from the second group session are presented. This list will also be limited to ten entries.

1. **Customizable (300)** It should be possible to customize things. Be it the appearance of the pet, the look of its den, or the garden of the player. This is a bit more broad then just the notion of a customizable pet appearance.

2. **Progress (200)** The game must have some kind of progress. The idea is simply to have the player progress in some way by playing the game, be it leveling up through getting experience points by performing different activities, or unlocking items by collecting certain items in the world.

3. **Appearance (200)** Customizable appearance, but not that it could be easily changed, which was covered in the Customizable idea at the top of this list. Appearance in terms of how the pet, the terrain and the game looks is important in general, since it is easier to like a game that looks good.

4. **Mood (85)** The pet should have some kind of mood. This would impact a lot of things, from how fast the pet learned (gained experience) to how much health it gained from walking. The mood would be reflected by the appearance of the pet, and could be altered by feeding the pet and taking care of it in general. The mood would also motivate the player to take better care of their pet, in order to keep it happy.

5. **Personality (50)** The notion of a personality, taking the mood note one step further. Some pets should react differently during different activities, or when consuming different kinds of food. The personality could be altered slightly by the player, but in major ways only by completely swapping pets. The notion of personality was also aimed at making the pet more lifelike, since real pets have very different personalities.

6. **Lethal (50)** The pet should be lethal. This idea, at first glance, does not seem like something positive. The idea arose when the group was discussing the appearance of the pet, combined with the idea of having pets battle one another, and that a pet that looked as if it was lethal would be a good asset in such a situation. Some members of the group reveled in the thought of having their pet battle and defeat other pets, while some members thought this was a terrible idea, and would have no part in it. The group concluded that battling should be optional, if implemented within the game.

7. **Reachable (46)** The pet should always be reachable from wherever you are. The player should always be able to check on it to make sure that it is happy and well. The pet should also be reachable from the same player account, regardless of device.

8. **Activities (45)** The ability to do something with your pet. The general idea is to have lots of different activities that the player and the pet can perform together. The activities note is an umbrella term for all of those activities. Among those were, for example, different kinds of mini games, like fishing, throwing a ball or hide-and-seek.

9. **Upgradable base (40)** Have a base or home for the player and the pet that could be upgraded or improved in some way. Decorating the base was also something that came up during discussion of this idea. The idea would tie in tightly to the progress idea further up on this list, where progression would result in decorations and upgrades for the base.

10. **Stats (27)** The concept of stats for the pet. Stats (short for statistics) is a common notion in many games. For Augotchi, there could be two kinds of stats. The first kind of statistic is data presented in a statistic page for the player, where he or she can see, for example, how many steps has been taken or how long the pet has been alive. The second kind of stats are certain attributes associated with the pet and its ability. This is something that can also be seen in many role playing games, with some example stats being health points, strength, agility and intellect, describing

how strong, fast or smart the pet would be. If a system akin to pet battling would be implemented, stats would be useful in order for the battles not to be based purely on randomness.

Both of the groups did the lists on their own, with no information regarding what the other group had come up with. It was no surprise that both groups picked categories as customization, appearance and progress as their top picks of ideas. The importance of the appearance of the pet can not be overstated, as well as the users ability to customize it until they feel it's "their" pet, as discussed in Section 3.2, additionally, the appearance must avoid the uncanny valley described in Section 3.4. Progress is something that we found to be fundamental to both games we did a formal game analysis on, which can be read about in Section 2.4, so that both group valued this highly is understandable. What can be said more is that both groups strove towards making the pet more lifelike in many ways, through different means. The differences that can be observed was that the first group focused more on properties of the pet, and what the pet would do, compared to the second group which focused more on the game play of the game, and what would actually be fun to do in a game and how the player would not become bored. Both of these aspects were considered important prior to the workshop as well, but having these predictions expanded and confirmed from an external source would prove useful when moving onto planning the features of Augothci.

The final observation made from these lists is what actually got implemented in the final prototype. The most important idea they picked, that of customizable appearance and customization in general, is now a central theme in the game. Gene manipulation and personalities were considered as well, but were deemed hard to realize, given the time span of the project. However, communication in the form of expressive animations, as well as mood of the pet were things developed for the game at a very early stage. Some of the ideas that the participants generated regarding how to make the pet more lifelike were also implemented. The ideas of stats and an upgradable base were brought up again in the second co-design workshop (see below) and is thus something that is part of the final prototype as well. Tied in with this is also the customization of the base, and the progress of unlocking and paying for these decorations. For a full list of features in the final prototype, see Section 7.1 on the Augotchi prototype.

6.5.3 Feature Categorization and Election

When deciding on what features would be added to the application, the ideas that the students had generated, and those that arose as a result of the co-design workshop, were transformed into features and then categorized in terms of importance. This meant that later, during development, the selection of features to implement each sprint would be quick and efficient. Several different categories were utilized, ranging from the most important features, to features that were desired, to minor features that could be implemented if spare time was found. When deciding what feature to place in what category, a simple evaluation was made, in which the feature's cost-value ratio was discussed by the

team members. The value of each idea was heavily influenced by the results from the first co-design workshop, while the cost evaluation was established by anticipated workload for each member.

6.6 MVP Development

The MVP development phase was the first phase of development, in which the first version of the prototype was developed, prior to the planned iterative development cycle. The development sections are named after their respective versions of Augotchi, as they were published on Google Play. Each version represents a development iteration. In total, seven iterations took place.

6.6.1 Version 0.1 - First Implementation

After the categorization of possible features. another list of features and mechanics was constructed with items that would make it into the first version of Augotchi. The number of features, as well as their cost in terms of development time, were considered in order to make the prototype feasible to develop in a two week time span.

The first week of development mainly revolved around creating the foundation for Augotchi, with the most important part being the pet itself and the system which saved the pet's status to local memory, and made sure it deteriorated over time, even when the application was closed. A player object was also created which represents the player on the map. Similar to the pet, it had a 3D model and animations for walking and standing still.

The game was decided to be divided into three different scenes in order to make each scene easier to manage and maintain. Each scene also had unique functionalities and a specific purpose. These scenes were the world scene, the home scene and the pet creation/customization scene.

Since the world map integration had already been implemented and tested during the technology research phase, see Section 6.2.2, not much work had to be done on that specific topic. However, some effort was put into making the game feel smooth and pleasant. A zoom limit and camera rotation was introduced, with the aim of producing controls similar to those of Pokémon GO.

In general, the work process was smooth, and none of the predicted possible issues arose. Essentially, all the external libraries, and Mapbox in particular, delivered what was promised without major complications.

After about five days of development, the MVP was almost finished, and it became clear that the time estimation during planning had been severely overstated. Since the

development started three days early, there was now eight days left until the original deadline of the MVP. After some discussion, it was decided to expand the MVP and make it more interesting, rather than entering the iterative process immediately. Technically, this expanded MVP would still be an iteration, but it would not be based on any feedback from external testers.

6.6.2 Version 0.2 - Expanded MVP

The most important feature in the expanded MVP was the expansion of the pet customization system. Before this expansion, the customization system could result in about 250 different pets. This was decided to be lackluster, as it was deemed important that the player felt that his or her pet was truly unique. Hence, the pet customization had to be expanded in order to allow for more pet combinations. First, the number of items in the already existing categories, such as ears and tails, was more than doubled, which would increase the number of possible pet combinations from about 250, to around 70000.

The next topic of discussion was color, which could be done in a multitude of ways. Either the pet could simply be one color, which would be the easiest to implement, or there could be a predefined set of color patterns for the player to choose from. However, it was decided that a more sophisticated coloring system would be implemented, which would paint the pet in three layers, each with its own parameters, similar to how creatures are painted in the game Spore [100]. The reasoning behind this choice was that, although it was the most costly solution in terms of development time, once finished, it would result in an exponential growth of possible combinations as assets were created. There would be 8 parameters in total, each with a number of choices, which would ultimately take the pet customization system from about 70000 possible combinations, to over 8 trillion, which makes it unlikely for two players to create the exact same pet.

The next problem to solve for Augotchi was progression. An important part of most games is that the player feels like he or she is getting somewhere, and that the effort put into the game leads to a rewarding experience. The first MVP definition of Augotchi lacked any inherent progress, other than perhaps striving to keep the pet alive for as long as possible. Next to the customization, this was deemed the most important issue to solve in the game. A number of different ideas and basic concepts had already been discussed throughout the project, and most importantly, during the conceptualization phase. Some of the systems that were discussed as viable alternatives were:

- Battling: A lot of games have either violent or competitive features that allow players to compete with non-playable characters and other players alike. One prominent idea has been to give the pet additional statistics like strength, stamina, agility and intelligence, which can be trained and maintained for later use in battles against other pets or wild animals. This system would not necessarily be focused on violence, but could also feature competitions like running the fastest or jumping the highest. This would take Augotchi in a role playing game direction, where the effort

put in is mainly reflected by the power level of the pet.

- Base Building: The player would construct some kind of nest for the pet, which could passively generate currency and which would have to be managed and furnished. This is a popular concept in many games, including mobile games like Clash of Clans [101] and browser games like Travian [102], or even Farmville [103]. This format, in which the player occasionally logs in for short periods of time in order to check up on things, could work well with the Tamagotchi-like aspects of Augotchi. However, it would be hard to combine with the fundamental walking mechanics of AR. In such a case, the base building would probably be combined with some sort of collection aspect, in which the player collects items for the nest in the real world.

- Socializing: To be able to meet other players and their pets within the game has been discussed as well. A possible friends system could let players help take care of each others' pets, and game tasks could be implemented which required players to cooperate. However, it would be hard to test such a system, since it would require a substantial player base for enough multiplayer interactions to occur. On the other hand, it could possibly make people more prone to inviting their friends to try out the game.

- Collecting Items: This is one of the fundamental aspects of Pokémon GO, and was the first solution chosen for Augotchi. One of the reasons being that Pokémon GO players ranked the collection of various in-game objects as the most important aspect of the game. Another reason was that it was deemed relatively easy to implement, hence feasible to get done in a stable manner within the remaining MVP development time.

In addition to clothing items, and a new map marker which allowed the player to collect them, experience points and player levels were added to the game. This is a simple feature that gives the player a measurement of how much he or she has played the game, but would also be helpful to track once data would be collected from the players, since it would give a clear indication of how much each player played the game.

At this point, some of our colleagues and friends were invited to try out the application and report any bugs encountered, as well as providing feedback regarding the game and its features.

6.7 Iterative Development

Iterative development is one of the most common ways to develop software. It offers high flexibility with ways to rethink and restructure customer requirements. Due to its effectiveness, it has become one of the most common standards in the industry. Furthermore, the flexible nature of iterative development makes it ideal for this type of project where requirements can change at any time.

6.7.1 General methods and Documentation

During the iteration phase of development, some general methods were used. Among these, the most central was the Agile methods. Several methods were considered, one of which is the method of SCRUM. However, since a small team of two individuals allows for more flexibility, the method was adjusted to better fit the anticipated needs of the project. Usually SCRUM tends to be fairly strict to fit a corporate standard where hard deadlines are set and have to be followed. For Augotchi, however, the more relaxed version worked well, since time estimates were often hard to pinpoint and new requirements arrived almost daily.

Another method used a lot was road maps in various forms. As mentioned previously, a team of two is easily administrated, and road maps proved to be superior to more complicated methods, which meant that personal lists quickly replaced the SCRUM-board, which was used in the start of the project. This made communication highly important, and the work would probably suffer, had not the team been working in the same physical spot.

A crucial aspect of any project is documentation. Documentation can come in many forms, from documenting the code a programmer writes, to documenting what certain people did during certain days. To what level it is necessary to document the work is an important question which has to be answered. During this project, the documentation of everything work related have been of high importance. Thus, efforts were made early in order to automate documentation as much as possible. The manual documentation can be found in the form of a daily log written by the members of the team. This, however, was more important during the first weeks (when nothing yet was being developed) as well as after the development. The reason for this is a powerful tool which provides automated documentation, Git [104]. Whenever work was uploaded to the Git cloud, a comment about the contents was added, and time stamps were automatically generated as well. This means that every single created file and change in code may be backtracked to day one, which gives a clear and accurate picture of what work was done, and when. The second service used which provided automated documentation was Google play [105], and more specifically, the Google Play Console [106], which is Google's tool for publishing Android applications on the Google Play store. After each iteration, a new version was uploaded by using the Google Play Console, which meant that a history was generated, containing all previous versions of Augotchi with the respective changes to each version. This proved useful when writing the report, as there were no doubts regarding what was done at what point during the project. This does require that the author writes appropriate release notes to go with every release, a task that was executed with care, since it is also important to the people who have already downloaded older versions of the game.

Each iteration, the work was divided between ourselves in a manner that would even out the workload. When developing a new feature which is content heavy, it is expensive in terms of time consumed for the programmer at first. However, if executed and designed

correctly, once the system is in place, the technical implementation of new content takes almost no time at all, and the workload is instead shifted to the artist, who needs to create new time consuming assets for each item handled by the system (e.g carrots for the farming system). One task in the beginning of almost every iteration, was to assess the time it would take to implement a new system, and then plan an amount of content which would take the artist an approximately equal time to create. Hence, near the end of each iteration, the content and the system were finished at the same time, which resulted in a smooth and effective work flow. Furthermore, since the systems were designed to be easily expandable, the exact amount of content could be either increased or decreased on a whim, without causing any problems.

6.7.2 Version 0.3 - Player Data Collection

Early on it was established that player data would be gathered and monitored in order to get a better understanding of how the game was played. Data such as steps taken, time active and the chosen visuals of the pet could all be valuable information. Far North Entertainment provided a web hosting service for this purpose.

An SQL database [107] was set up, and API endpoints were created, using PHP [108], which would allow the application to post the player's data to a database table, which stored a number of data points, including the ones mentioned previously. It is important to note that no personal data, such as player location, email address or name, were saved in this table. The data was anonymous, and used a special value generated by Unity, as a unique identifier for the device which run the application. This identifier made it impossible for the team to link player data with any personal information.

6.7.3 Version 0.4 - Player Convenience Update

With the data collection in place, the application was ready for testing. However, before searching for potential testers, some changes were made in order to prepare the application for external testers and make sure there were no obvious flaws present in the game, as well as making the pet more personal.

The first change was to make the pet customization permanent. Once the pet was created, its looks could no longer be altered, except for changing its clothing. A feature for naming the pet was also introduced. Some effort was also put into making sure that the player would not make unfortunate mistakes. This was done by adding a verification popup to the pet creation, explaining to the player that, once the pet had been created and named, it could not be altered in the future.

The second major feature of the update was the tutorial screens. Some of the mechanics in Augotchi are not obvious in how they work, most notably the status values and how they deteriorate. Tutorial screens were added which explain the game and its mechanics

in detail, in order to avoid any misunderstandings that could arise.

Since there was some time to spare, a statistics screen was introduced, which let the player see some of the more important statistics saved in the database. Total steps taken while playing Augotchi and the total time that they had kept their pet alive are examples of the data that was shared with the player.

Some smaller features were put in as well. Most notably clothing rewards every time the player levels up, and a system which spawned map markers differently dependent on pet mood.

This was considered a polishing update. Once it was implemented, Augotchi was deemed ready to be tested by external users on a large scale. Up until this point, the development had been focused solely on creating a prototype that would be fully playable, and which kept a reasonable quality, in terms of both coding and visuals. This goal was considered met, as so far, development had been free from major disturbances, and since Augotchi had a number of features not previously expected to make it into the first tested version.

6.7.4 Recruiting Testers: Wave 1

With the application ready for testing, a first attempt was made to recruit testers for the application. There were two plans for tester recruitment.

The first plan was to find at least eight individuals who would like to play the game and later participate in a couple of focus group evaluation sessions. These sessions would be hosted in Gothenburg, which meant the participants would have to be able to physically attend these meetings. The target age group was young people, aged 18-30. The main platform of recruitment was Facebook and Google+, which had a number of active communities in Gothenburg for similar games like Pokémon GO and Ingress. Administrators in the respective groups were messaged, in order to gain permission to make posts in these groups, asking for help. The posts focused on recruiting focus group participants, since they were mainly seen by people from the Gothenburg area.

Since it was anticipated that focus group members could be hard to find, a secondary plan was also executed. The quick surveys which had previously been posted on Reddit had been more successful than anticipated, with more than four thousand responses in total, and with the posts being highly rated in their respective forums. If at least one percent of the respondents of these surveys downloaded and played the game somewhat actively, this would be forty testers, which would be a reasonably sized group to later work with in various ways. New posts were created and posted in the same forums, in which we presented ourselves as the creators of the previously popular surveys, asking for some help with the master thesis. The idea behind this recruitment was that people would play the game, and data would automatically be gathered in the database, which

would lead to quantitative data being gathered with little to no effort required.

This wave resulted in one potential focus group participant, as well as ten downloads of the game on the Google Play Store. Hence, the first recruitment wave did not yield the results that were deemed necessary for the project, and a second wave was therefore conducted. This second wave is described later in this section.

6.7.5 Co-Design Workshop II

The second co-design workshop was done in a similar way to the first. The same groups as the previous workshop were gathered, and the time and place of this workshop was similar as well. The difference, however, was that both group sessions were performed during the same day, having one session range from 10am to 1pm, and the other from 1pm until 4pm. These sessions were also planned to be longer in order to avoid going over time. This was important since the groups came one after another, and going over time would mean that the second group would have to wait.

The first co-design workshop was aimed at generating ideas for things that the participants would want to do in the application, as well as finding out how they would like to form their pet. The second workshop had a different aim. Prior to the arrival of the participants, in preparation, the team had come up with five themes that would shape the game. These five themes were:

- **Fighting:** A battling system where you would fight with your pet, similar to Pokémon.
- **Base-Building:** A system for customizing your pet's home and/or build a home for it.
- **Shops and Economy:** Intended to bring some player-to-player interaction, and make the players able to sell and/or trade things to/with one another.
- **Questing:** A system which would continuously provide the players with tasks to complete, both in the short term and in the long term.
- **Socializing:** Find ideas for things that players could do together in a multiplayer environment.

The desired outcome of the second co-design workshop was to be able to expand the game by picking one of the five themes to be implemented. All of the themes were designed so that it would add a new dimension to the game, and thus granting it more depth and content. When describing these themes to the participants it was kept brief, in order to avoid skewing the participants' expectations of the themes more than necessary. The themes should have been familiar to the participants as well, since they had been touched

upon during co-design workshop 1.

Since the second co-design workshop was to be less divergent than the first one, it was more moderated. Not only were the ideas of the participants asked to be realistic (since the ideas were actually going to be used in order to construct the application). This time, discussions were quelled when they derailed too far. Furthermore, since three of Far North Entertainment's employees partook, an education round about game design was added to the workshop.

Figure 7: The participants evaluating pros and cons of various themes

Following is a brief summary on how the second co-design workshop was carried out:

- **Introduction** - The participants were introduced to the workshop and its goals.
- **Presentation of themes** - The five themes that they would be working on were presented. The introduction of each theme was brief in order to avoid influencing the participants' perceptions of the themes. It was explicitly pointed out that the results of the second workshop would be used directly for future development.
- **Short break** - The participants were given a five minute break.

- **Pre-brainstorming round** - During the pre-brainstorming round, the group was asked to once again do a version of the "stickies" brainstorming method, which had worked well in the previous workshop. The participants were given some time to answer the focus question and were then asked to pick their three favorite notes to be pinned to a board. This process was repeated for the five different themes, thus expanding the concept of each theme.

- **Picking a theme** - During this round, the "pros-and-cons" evaluation method was used in order to determine what theme the participants were most interested in. The participants had two cards per theme, one pro card, and one con card. Each person got to pick one pro and one con, which were then written on the back of the cards. The cards were shuffled, and then ranked based on what was deemed the most important pros and the most serious cons. The results were used as guidelines when picking a theme to continue with. (The results of the cards were not followed blindly, but gave the participants a guideline for what could be good or bad with each theme).

- **Long break** - The participants were offered coffee and cinnamon buns. It was only a 20 minute break this workshop, based on the insights from executing the first co-design workshop.

- **Post-brainstorming round** - A variant of the "mind map" brainstorming method was used. Three circles were drawn on the board, and then, four post-it notes from the earlier stages were placed inside each circle. The participants were then asked to write additional post-it notes that could be added to one of the circles. This resulted in three different concepts. A quick voting round was held, in which one concept was elected as the final winner.

- **Short break & crash course in gameplay design** - The participants were given some time to relax. Meanwhile, a short presentation was held, which presented theory related to game play design. This presentation was planned to be roughly ten minutes, but was cut short due to time constraints.

- **Make a game** - During the last round of the workshop, the participants solidified the concept that they had created, by describing it in game play design terms (game play design patterns and game play mechanics). The results of this round would be concrete ideas for actual game implementations.

- **Outro and presentation of results** - The participants were thanked and the final results were presented. Last minute comments were gathered and questions were answered.

As with the first co-design workshop, whenever a brainstorming technique was utilized, it was important to let the participants know what questions they were expected to answer. Thus, a number of focus questions were defined. For the second co-design workshop, they were:

1. Pre-brainstorming round: *What features/aspects would there be in the respective themes?*

2. Post-brainstorming round: *What would be three unique ideas for how the theme could work in the game?*

3. Make-a-game round: *How do you visualize this concept in terms of game play design patterns and game play mechanics?*

Co-Design Workshop II Results
The desired result from the second co-design workshop was a set of game play mechanics and a set of game play design patterns. The following list is the results generated by the participants of the first group, which decided to explore the theme of base building:

- **General concept - base building**

  - *"Albion-esc; you make a foundation and farm mats and put on."*
    Albion online [109] is a MMORPG that most of the group's participants had played before. In Albion online, the player first places a foundation on the ground, and then head into the world to cut down trees and gather stone in order to construct a house upon the foundation. The construction process is modular, giving the player a lot of customization options.

  - *"Upgrades of basebuildings."*
    Due to the modular nature of the construction, there is much room for the player to upgrade parts of the house in order to increase efficiency in some way (or simply to make the base more pleasing to look at). This ties in a lot to the progression and customization ideas from co-design Workshop 1.

  - *"If you do not look after your house, you'll have to pay Anticimex to tidy up."*
    Anticimex [110] is a Swedish company that focuses on pest control, food safety, moisture control and fire safety. The idea behind this concept is that if you do not take care of your house, it will deteriorate, and you will have to spend resources in order to keep it tidy. In a sense, the house would have mechanics similar to the pet's, similar to a Tamagotchi.

  - *"Garden! pls pls pls" & "Grow food for pet"*
    These two post-it notes have a similar meaning. The first note states "pls" which is internet slang for "please", so the author of the note was pleading for this garden feature to be implemented. The second note state that you should be able to grow food for your pet in the garden, granting the garden a purpose, rather than just aesthetically improving the area around the base.

  - *"Home base where the pet does not die"*
    the Tamagotchi concept means that the pet becomes hungry and depressed if you do not look after it. This idea suggests the pet should not die if it is in

close proximity to the home or base, giving it another useful purpose.

  - *"Send pet on quests to find materials"*
    You should be able to use materials to build and construct useful or pretty things, thus consuming materials. To be able to send your pet to fetch these well needed materials for you, would connect the pet to the base building, making the pet more useful.

- **Gameplay mechanics**

  - Walking - In order to get building materials for base construction.

  - Building - The main feature of this concept.

  - Repairing - To look after your base so that it does not deteriorate.

  - Fishing - Nice relaxing activity, not necessarily specifically connected to base building.

  - Razing - To be able to raze buildings, in order to make room for other things.

  - Decorate - To make the base look pretty for friends who visit.

  - Seed, water and fertilize - To plant and look after crops planted in the garden.

  - Coloring - To be able to color different parts of your base in order to increase uniqueness.

  - Visiting - To be able to visit friends' bases, see what they have created, and to invite them over to your base in order to show them what you have created.

  - "Pedestaling" - To show of rare things you have found or constructed on some form of pedestal. (The word was invented by one of the participants on the spot).

- **Game play design patterns**

  - Plants - The concept of having crops.

  - Farming - The concept of planting and reaping those crops.

  - Bases - The core concept.

  - Resource management - To be able to decide when and how to most efficiently spend resources.

- Collecting - Collecting rare decorations or plants for your base and make it look more impressive.

- Pet find loot - The pet actively partakes in the base building process.

- Exploration - To go out in the world and see things you haven't seen before, and make it feel rewarding.

- Weather effects - To have different weather in the game that impacts game play in different ways (For a true AR game this would preferably be locally matched to the real life weather at the players location).

- Upgrades - Upgrades for the house, base, crops or garden.

- Income - Some way to earn resources.

- Player-designed buildings - To have the player be able to design, in more detail, how the base would look.

- Upkeep - The concept of paying resources in order to keep the base from deteriorating.

- Be more proficient - To be more proficient in whatever task you put work into.

- Safe-zone - As talked about earlier, that the pet would be safe near the base.

- Seasons - That the seasons of the year would impact game play in different ways.

The second group, instead of picking base-building as a theme, chose to explore the theme of questing. It is worth noting that base building was one of the top two picks for the second group as well, but as it got tied for the theme to pick, the hosts stepped in and settled the tie by picking questing, in order to increase diversity.

- **General concept - questing**

  - *"Ongoing story in different parts" & "Bond with your pet through the story" & "Tearful story"*
    These three ideas had a similar meaning. The concept is clear, namely to have a story in the game that is ongoing and beautiful, and where you can bond with your pet along the way.

  - *"Quests are of different difficulties depending on your pets specialization"*
    Fairly self explanatory, the concept, however presumes, two things. The first is that there is different types of quests, the second thing is that the pet can be specialized in some way to be able to more effectively complete different

kinds of quests.

- *"Expansions"*
  Expansions, or downloadable content, is a common game concept. What usually comes with the expansion of a game is more content and continuation of the game's story; something that this group was very focused on.

- *"Rewards that you can customize your pet with"*
  The rewards for completing the quests could be cosmetic apparel for the pet, or other items that would alter the pet in some way.

- *"Social quests where the player would meet other players"*
  This concept is intended to enhance the meetings with other players while playing the game, something that is seen in other similar games, which is one of the genre's unique features.

- *"Get quests from NPC"*
  To make games feel a bit more like a living world, instead of empty. Many games put non-player characters in the game world. The players could receive tasks from such characters.

- *"Mini games in the game (For example catch mice with the cat and so on.)"*
  The concept of having small independent games within the game in order to get specific rewards from them, or to make the game more fulfilling. There could be many kinds of mini games, for example fishing, which was mentioned by the previous group. Mini games are also quite common in other games, including Pokémon GO and Ingress.

- *"Random bases that spawn every day / Attack!"*
  An example would be combat against a neutral NPC base, such as a bandit encampment, that would spawn randomly every day, granting the player a reason to open up the game daily in order to perform this task.

- *"Go to a location and gather quest items, locations can be famous sites IRL"*
  IRL is an abbreviation for "In Real Life". This is another example of a type of quest that have the players explore the world and see famous landmarks, such as statues or monuments, in order to gather items for the quests that the player tries to complete in the game.

- *"Global timed raiding quests"*
  Yet another example of a possible quest type that could be implemented. The concept is that the quest is global and timed, meaning that all Augotchi players get the same quest at the same time. That it is a raiding quest means that it would require several cooperating players in order to complete the quest.

- *"Store offers for quests IRL"*

IRL again meaning "In Real Life". This concept paints the picture of a player who completes a quest in the game and receives a coupon for something in a real life shop.

  - *Ending credits*
    The idea of ending credits is that the developers of the game have a page in the game stating that they were the ones who made the game. This concept came up since one of the participants found it reasonable that they would all be in the ending credits for their hard work, and thus the game needed to have ending credits.

- **Gameplay mechanics**

  - Tap bulletin boards to get quests - A suggested way to get hold of quests in the game.

  - Take care of your pet - While reasonable, it has not much to do with questing.

  - Get notifications of quests in the app in the morning, different alternatives - To automatically get the results of yesterday's questing in the form of Android notifications, and being able to collect the rewards.

  - Capture points of interest & put out markers close to where many would have wanted a marker - These points refer to the same concept, to be able to claim a location with your marker for some predetermined reason.

  - Inspect: markers, players and NPCs - Again, NPC meaning "Non-Player Character". The mechanic refers to the ability of taking a closer look at markers, players and NPCs.

  - Walk around - A core mechanic of location-based AR games, and a possible way to complete quests.

  - Form teams with other players - As stated earlier, the multiplayer aspect of any AR game have potential to be a major part of the game. This concept capitalizes on the multiplayer aspect and how it could be used in order to get players to cooperate and make something together.

- **Game play design patterns**

  - Factions - To have different factions in the world, each having a personal standing and relationship status with the player.

  - Reputation - The standing a player would have with a faction.

  - Daily quests - Small repeatable quests that can be completed once every day.

– Daily quests that reward reputation - You perform daily tasks for a faction, and they like you more as a result.

– Relatively small pool of possible daily quests - If the player has too many different things to do every day, it might lead to the player becoming overwhelmed and confused. Furthermore, a small number of daily quests would be easier to implement.

– Daily quests appear in a specific place and at a specific time, fixed locations for daily quests & find NPC at the map to get the quest - These three ideas all point toward the concept that quests should be received at fixed points, and at the same time every day, so that the player can plan accordingly.

– Wandering quest givers - The opposite of the previous list item. A quest giver that wanders around and can be found almost anywhere. What this does is giving the player a sense of variation and exploration.

– Player created quests that can be put up on quest boards (that can be found all over the place) - The players themselves can give quests to other players, this is again to strengthen the multiplayer aspect of the game, and to have players working together. Also, if players create the content for fellow players, the game may feel a lot less shallow.

– "War" as in Ingress between factions - The concept here is simply to implement a system which resembles that of Ingress, in which players combat each other for control over map locations.

– Escort quests - This is another type of quest, where the player has to walk with an NPC to a certain point, protecting it along the way.

– Completing quests with other players grant more XP - XP here is a gaming term for "experience points", it is the primary way to level up in many games, and a common reward. This could also improve on the multiplayer aspect.

– Relatively easy to complete - This concept suggest the quests should be relatively easy to complete. Players should not end up stuck with difficult quests.

Figure 8: Refinement of the various themes

It is hard to compare the groups' answers with one another, since they focused on entirely different aspects of the game. However, it can be determined that the results were in line with what was desired. And even more so, the different themes the groups explored works well with one another. Questing is a "granting" activity, meaning that the player invests time into it, and gets resources, materials or other rewards a a result. Base-building is a "consuming" activity, meaning that it consumes resources and materials when the player constructs things. These two coupled together gives the player a clear game play loop, where he or she completes quests for resources, and then spends them by building and improving the base.

Both groups focused on what would actually be done in the game, probably because the task was formed in a way that would promote such an outcome, but what is more important is that both groups seemed to take multiplayer into account, and made it a central aspect of both concepts. Also what is interesting to compare is what the groups' concepts looked like compared to what actually got implemented into the game. While many things differ, more on the questing/story front that the base-building, many of their concepts actually made it into the game.

6.7.6 Recruiting Testers: Wave 2

During the development of version 0.5, a second wave of recruitment efforts took place. While the ten downloads from the first wave was not considered terrible, a majority of

the new players simply started the application, created their pet and then never opened the game again.

In the second wave, an attempt was made to make the online recruiting more personal. A video was made in which one of us voiced a script which explained the goals of the thesis and how the viewer would be helping by simply downloading and playing the game. Throughout the video, there was game play footage of Augotchi, so that the viewer would get an idea of what the game is like.

We also asked for help on their personal facebook pages, seeking focus group participants, which could be friends of friends or family.

The second recruitment attempt did not yield any new potential focus group participants, but did lead to a total of 48 installs, which was an acceptable number. However, the number of people who actually played the game was still too low to be useful, as most of these individuals were the ones already being part of the project through the co-design workshops. A third wave was therefore conducted during the later stages of the project, which is described later in this section.

6.7.7 Version 0.5 - Augotchi 2.0

The second co-design workshhop had resulted in two new concepts being formed for Augotchi: base-building and questing. In addition to these concepts, some other issues had been identified that needed to be addressed in order to improve Augotchi's game play. The new systems which make up the base-building, farming, shopping and questing mechanics were all introduced in 0.5, and are all part of the final result. This section will instead focus on the changes made to the already existing features of the game, even though the development of the new systems was the main focus of this iteration.

The first major change was the redesign of the marker system. The previous system was considered boring and too repetitive, since the markers were always visible, and since their positions had low variety. The issue with the markers being visible was that, whenever a rare marker spawned, it was immediately seen by the player, and the game therefore revolved around grabbing random markers until a rare marker spawned, in which case, it was hopefully in a reachable spot. The feeling of walking away from a rare marker simply because it was unreachable, or because it was in the wrong direction from where the player was heading, was an unsatisfying one.

Hence, the decision was made to make all markers invisible, and in order to compensate for this, triple the total number of markers. Whenever the player approaches an invisible marker, it pops up on the map. Marker generation was also remade. Previously, the markers had spawned in a ring around the player, and once a marker was taken, all markers disappeared, and a new ring was spawned. The idea behind this design was to make Augotchi playable anywhere at any time, as at least one marker would always be

in a reachable spot. This principle was kept in the new system, which features a "cloud" of markers, which spawns semi-randomly around the player, and which dynamically regenerates itself as the player moves. Eight markers are still created in a circle around the player, but in addition to these eight, sixteen markers are also created completely randomly. The intention of these changes was to make the game feel more unpredictable, entice a feeling of exploration and make the finding of rare markers feel more significant. In essence, it was an attempt to make the game more exciting.

Another major change was the remake of the pet resurrection mechanic. Previously, when the pet passed out, the player had to gather ten hospital markers in order to revive it. This system had to be re-implemented due to the previous marker changes, and was done so in its entirety. Instead of gathering ten hospital markers, the pet is now revived by using a special item, which can be found on the map in the shape of a rare marker. The idea behind this change is that players that keep their pet alive for longer periods will typically have this special item available, should the pet pass out. If the pet passes out without the player having the revive item available, the player's punishment is a bit more arbitrary, and less predictable. The punishment still involves walking, but the distance changed from a fixed 3-4 kilometers to anything between 500 meters to, theoretically, infinity (Since it was now based on a randomized element).

6.7.8 Recruiting Testers: Wave 3

Since the second recruitment attempt did not result in a desired outcome, it was obvious that presenting the thesis in June would not be possible if any significant external user testing was to take place.

A new plan was devised with the aid of the supervisor in which we would contact upper secondary schools in Gothenburg, in order to see if there would be an interest among their pupils to participate. Emails were sent out in waves to all upper secondary schools, and their respective principals, in the Gothenburg region. The mail explained briefly what the project was all about, and that we needed help over the summer.

An issue that had become clear to both students was that a game like Augotchi is relatively hard to test in isolated sessions. Since it is an ongoing game which spans over time indefinitely, and since it takes place geographically in the real world, the setup for any testing is hard, other than some kind of evaluation session with people who have tried out the game for a while.

When the emails to the schools had been sent out there was nothing planned due to the lack of testers. It was decided to continue the improvement of the prototype while waiting for responses from the schools.

In the end, most of the schools did not respond to our email, and the few schools that did respond were either not interested in participating, or failed to find any interested

students.

6.7.9 Version 0.6 - Dungeoneering & Content

Steps had already been taken in version 0.5 to make Augotchi more interesting. Both 0.6 and 0.7 had the same focus, namely to expand the game and the options that the player has therein.

The new major features of 0.6 were the statistics strength, agility and intelligence as well as the dungeon exploration mechanics. These are explained in detail in Section 7.1. The main intention behind these features was to create a more lasting progression goal for the pet, as well as making the pet feel more useful to the player. Before this change, there was no enticement to play Augotchi extensively. The new statistics meant that progression is always possible, no matter how much time the player spends on the game, since they can never reach a maximum value.

Version 0.6 also greatly expanded the farming system with 9 new crops and also added two new rare markers which, on activation, granted the player special food items only found on the map. The new rare food alternatives are required in order to boost the new statistics of the pet, which in turn makes it more likely to succeed in exploring dungeons, which in turn results in relatively big rewards for the player.

6.7.10 Version 0.7 - Garden Decoration

The last iteration of development featured the implementation of the garden decoration system.

Similar to the pet statistics added in version 0.6, the garden decoration system was created so that the player would have another long-lasting goal within the game. Garden items cost building materials. are expensive to build, and there is no limit to how many items the player can place in the garden. This means that building materials is always a useful resource to gather. Since garden decorations could now be bought by Roger in the shop, coins also became more significant. In short, the garden decoration system was designed to make the two currencies of the game matter more, and to create a sink which make these currencies actually valuable.

Since this was declared to be the final version of the game prototype, some efforts were put into improving the game performance. The frame rate of Augotchi was improved by tweaking the Mapbox settings and the map-rendering camera, which increased the frame rate by over 300% on the tested devices.

With the game running smoothly, and with the new features in place, Augotchi was considered done for the sake of the master thesis.

6.8 Evaluating the prototype

The evaluation of the prototype was designed based on the sparse resources available to us. It would be performed by holding several evaluation sessions with participants from the previous co-design workshops. The members of these evaluation sessions were hand picked from the co-design groups, since they were the ones who had played Augotchi the most. Out of the group of eight co-design workshop attendees, four were chosen, two males and two females between the ages of 24 and 26. Note that the group of people chosen were all friends of ours. In order to avoid biased answers, the features of the application would not only be evaluated directly, but also compared to each other. The reason being that eventual bias would cancel out, since the participant would be equally biased towards every feature, since they were all created by us.

Each of the four participants agreed to be interviewed in an evaluation meeting. The sessions were conducted in four blocks, with a break planned half through. The four blocks were designed to represent one aspect of the game each: Pet creation, the Tamagotchi mechanics, the world markers and the ranch. The blocks themselves consisted of two parts. The first part of each block utilized a variant of the NASA TLX forms, in order to get numerical values representing the participants' ratings of the different features. The participants were asked to fill in the forms anonymously, and were assured that we would handle the returned forms in a way that would not give away their answers. Some modifications were made to the forms for certain topics to make them fit better. For example, in the "Pet creation" TLX, the parameter of "Physical demand" was removed and, another called "Creative Freedom" was added. An "Overall Enjoyment" parameter was added across the board. The second part of each block consisted of a discussion-like interview, where we posed questions and discussed the various topics with the interviewees. The results of the previously filled TLX forms were not discussed at all, instead other topics were brought up:

- **Pet Creation** - This block revolved around aspects of the pet creation of Augotchi. The individual topics covered were:
  - *"Do you feel your pet is unique to you? Does its appearance matter?"*
  - *"Is there anything you would like to see that is not currently in?"*
  - *"Randomize vs. create?"* - this question simply discuss whether the appearance of the pet should be randomized or created by the player.

  The parameters of the TLX were: Mental demand, Temporal demand, Performance, Effort, Frustration, Overall Enjoyment and Creative Freedom.

- **Tamagotchi** - This block revolved around the Tamagotchi aspect of Augotchi, in other words, keeping the pet happy and alive. The individual topics covered were:
  - *"What are your thoughts on the AR-genre fused with the Tamagotchi aspect?"*

- *"Thoughts on pet permanent death against the system in place now against having no consequence at all?"*

- *"Mini-games with the pet, would it help? Any ideas?"*

The parameters of the TLX were: Mental demand, Physical demand, Temporal demand, Performance, Effort, Frustration and Overall Enjoyment.

- **AR-World: Markers** - This section revolved around the AR-world, and more specifically, the aspect of moving around the real world map while collecting things by finding and pressing markers. The individual topics covered were:

  - *"Thoughts on static markers vs. dynamic markers?"*

  - *"Thoughts on hidden markers vs. visible markers?"*

  - *"Thoughts on effort put in vs. reward or enjoyment granted from walking around and picking markers?"*

  - *"Thoughts on clothing or unlocking of them?"*

  - *"Thoughts on questing or dungeoneering?"*

  The parameters of the TLX were: Mental demand, Physical demand, Temporal demand, Performance, Effort, Frustration and Overall Enjoyment.

- **AR-World: Garden** - This section revolved around the AR-world, and more specifically the ranch and its features, such as garden decoration and farming. The individual topics covered were:

  - *"What do you think of the first food system compared to the second?"*

  - *"Thoughts on garden decoration? Is it fun?"*

  - *"Thoughts on the economy of the game? Does it work?"*

  The parameters of the TLX were: Mental demand, Physical demand, Temporal demand, Performance, Effort, Frustration, Overall Enjoyment and Creative Freedom.

After the four blocks had been discussed, the participants were given two additional TLX forms. Two games had been picked that we knew the participants had played. These games were World of Warcraft [111] and The elder scrolls V: Skyrim [112]. Both games feature character creation systems, and the participants rated the character creation of those games respectively. The parameters of these TLX forms were the same as for the "Pet creation" TLX. The reason for having the participants evaluate the character creation of large established games, was to compare the results with those that they gave

Augotchi's pet creation.

When all data was gathered from the interviews it was structured in lists and then grouped into categories for easier reading. Since the interviews followed the same structure with the same major topics, some specific comments were brought up more than once, and thus, those were grouped in order to better understand how the application could be shaped in the future. In short, the categories were based on the different topics listed above, as well as the questions asked.

Below is a quick summary of how the various parameters of the TLX forms were explained to the participants when rating the different features:

- **Mental demand** - This refers to the amount of mental effort required to complete the task and relevant sub-tasks.
- **Physical demand** - This refers to the amount of physical work required to complete the task and relevant sub-tasks.
- **Temporal demand** - This refers to the level of stress one could experience, or how hurried the participant could feel, when completing the task and relevant sub-tasks.
- **Performance** - This is a measure of, to what extent, the participant felt like they achieved their goals of the task and relevant sub-tasks.
- **Effort** - This refers to the amount of effort the participant had to put in, in order to complete the task and relevant sub-tasks.
- **Frustration** - This refers to how much frustration the participant felt during the task and relevant sub-tasks.
- **Overall Enjoyment** - This refers to how much joy the participant felt when completing the task and relevant sub-tasks, or when exercising the task and relevant sub-tasks.
- **Creative Freedom** - This refers to the amount of creative freedom the participants felt they had whilst completing the task and relevant sub-tasks.

These differ slightly from the traditional NASA TLX setup. As mentioned earlier "Physical demand" were not present in all different sections, while "Overall enjoyment" as well as "Creative freedom" were added to better capture the desired data.

7 Result

The result section will present all the information generated during the project, more specifically it contains a detailed description of the Augotchi application prototype. The results from the evaluation sessions, as well as a brief presentation of the digitally gathered quantitative data, are also presented.

A video of the finished application can be found in the references [113].

7.1 Augotchi Prototype

This section will present the Augotchi prototype. All of its mechanics, features and content will be described in detail, with each subsection containing one specific area within the game.

7.1.1 General Structure

The Augotchi application was developed in Unity [72], which means that everything that takes place in the game has to be confined to what is called a scene, or level. Augotchi consists of three scenes which the player switches between while playing the game.

- The world scene - This is the main scene of Augotchi, and the scene which the player enters when starting the game (unless it is the first time the game is started, in which case the pet creation scene is opened). The world scene contains the world map, the world markers, everything related to the Ranch, the quest log and buttons for switching to the home scene and customization scene. This scene also contains interfaces for the player inventory, player experience and level, the number of steps required for pet health improvement, the tutorial screens, a sound toggle button and currency counts for building materials and coins. When playing Augotchi, the vast majority of time is spent in this scene.

- The home scene - The home scene is where the player interacts with the pet by feeding it. This is also where the player can check the various attributes of the pet, in order to better understand its needs and how developed it is in terms of strength, intelligence and agility.

- The pet creation/customization scene - This scene is used in two different ways. When the game is first opened, and the pet is created, it is done via the customization scene. If the scene is entered from the world scene after the pet has been created, it instead allows the player to choose a hat and a facial feature for the pet, if such items have been acquired.

The most important object in the game is the global pet object, which contains all data describing the game state. This is also the only object which persists through scene changes. Whenever a change in the game state is made, be it feeding the pet, collecting a map marker or taking a step, this object is updated, serialized and saved to the phones local memory. This new file contains all data necessary in order to restore the game state whenever Augotchi is restarted. When the MVP was implemented, this file was simple, and only contained the basic pet status values, such as hunger and happiness. However, over time it was expanded to contain hundreds of various parameters, describing not only the pet, but the player related values, inventories, the Ranch, growing crops, item unlocks and much more. These values will not be described in detail in regards to how they are defined or how they operate. However, the source code, in its entirety, can be found in the Augotchi Github repository [114].

Augotchi does, for the most part, follow what is called a model-view-controller design pattern [115] which means that the data describing the game state, and the visual representation of the game state, are completely separated. The prototype does not follow the design pattern fully, since during development, speed has trumped code clarity in many cases. The model part of Augotchi which in essence is the global pet object fully follows the design pattern, but the view and controller components are not as easily defined, and are mixed up in many cases.

7.1.2 The World Map

One of the central mechanics of Augotchi is the way the player moves around in the game world. Movement is achieved by changing the physical location of the device, and this is most commonly achieved by walking around. Mapbox, an external library, supplied the project with an excellent solution to this problem [75].

The world map consists of a set of tiles, each containing vector graphic information which describes the map portion represented by that tile. Once the GPS position is fetched from the device, a virtual camera in the 3D scene is used to define the bounds of the map to be rendered in the game (note that this is not the same camera as the one which renders the view of the game). By using this map rendering camera, it is possible to define how big of a portion of the world should be rendered in the scene. The further away the camera is from the player, the bigger the portion of the world which is rendered becomes. As the player moves, tiles end up outside of the camera's view, and these tiles are then removed from the game. Naturally, there are also areas created within the camera's view that are empty. New tiles are generated that fill these empty areas with new map information, which is fetched from a database during run time. There is also a cache stored locally on the phone, with map tiles already seen by the player, which means that areas that the player has already been to are loaded and displayed correctly without downloading the data twice.

Most objects in Augotchi are placed on the map, which means that when the player moves

across the world, the objects on the map moves relative to the players position.

7.1.3 The Pet

Apart from the map integration, the pet was the first feature to be implemented in Augotchi. In essence, the pet is modelled as a number of values, representing the status of the pet. This status is then reflected in animations of the pet, as well as in the UI of the various scenes.

The system for simulating the status of the virtual pet was freely constructed based on the interactions of the classical Tamagotchi. The three basic status values are hunger, health and happiness, all represented by a floating point value which reaches between 0 and 100. When one of those values reaches 0, the pet passes out, and when a value is above 75, it leads to benefits for the pet. What makes the values different from each other is the way that they are manipulated and controlled by the player.

Hunger deteriorates fast, but is relatively easy to replenish by using various food items in the home scene. Health deteriorates slowly, and can also be replenished by feeding the pet certain food items. Also, by taking walks with the pet, the player may increase the pet's health by 2 for every 100 steps taken, which is a mechanic designed to fit into the location-based AR setting specifically. Happiness deteriorates very slowly over time, but also depends on the current hunger and health status of the pet. If hunger or health is below 25, happiness rapidly decreases. If hunger or health is above 75, happiness increases instead. Happiness may also be increased by feeding the pet certain food items, or by petting the pet, which can be done once every hour. As such, happiness is a long-term value, which is first and foremost manipulated by keeping the pet satisfied in terms of hunger and health.

The pet's status values deteriorate once every ten seconds, what is referenced to as a "tick". A system was developed which retroactively applies any ticks which occur while the app is closed. For example, if the player closes the game and opens it up one hour later, the game will apply 360 ticks of deterioration to the pet. This means that the game is always running, and if the player is gone for too long, the pet will be in a passed out state when the game is reopened. The deterioration rates are set so that the pet has to be checked upon at least twice a week.

The second set of attributes of the pet are the strength, intelligence and agility values. These are also represented by a floating point value, which reaches between 0 and, theoretically, infinity. All of these power attributes start at 0, and can be increased by feeding the pet some of the rare food items in the game. By increasing these values, the player increases the chance of the pet being successful when exploring dungeons. A mathematical function was developed which slows down progress as a value increases:

$$P_n = \frac{500}{P_o + 500} * I$$

Where P_o is the current stat value of the pet, I is the food increment value and P_n is the resulting, new stat value. If the pet is fed a food item which has a strength value of 10, and it already has 2000 strength, the resulting actual increment will be 2. This makes it difficult to push any value above a couple of thousand, which was the intention of the formula, since the maximum difficulty rating of a dungeon is 2500. All of these secondary values deteriorate by about five points every day, which means that the formula also makes it harder to maintain a high stat value than a lower one.

The direct actions taken towards the pet all happen in the "home" scene. This scene consists of a list of buttons for feeding the pet various food, an animated 3D model of the pet, as well as UI elements which displays the current hunger, health and happiness of the pet. There is also a button which takes the player back to the world scene.

In the world scene, the pet is displayed on the map alongside the player character object. A simple behaviour script was created for the pet, which has it roughly follow the player around, while exploring its surroundings. The pet object is purely cosmetic in this scene, and cannot be interacted with in any way.

7.1.4 Pet Customization

An important result of the co-design workshops, was that the participants wanted to feel like they had a unique pet. The proposed solution to this desire was to implement a pet customization system, in which the player can design the pet. In Augotchi, the customization of the pet consists of eight steps, each consisting of one to three parameters.

The system for pet colorization is made in such a way that there are three layers of textures applied to the pet model. The base layer covers the entire pet and gives it its main color. The overlay layer defines the main complementary color, and covers large portions of the model. The last layer is the details layer, which adds details like stripes or dots to the pet. Each layer has a texture, which determines how the fur or skin of the animal looks for that layer. Every layer also has a color component that colors that specific layer. Finally, each layer has a mask which "hides" the layer in certain areas (represented by black pixels) and shows it in other areas (green pixels). This allows for greater customization, since it makes it possible to freely mix the colors, masks and textures of the layers.

In the figure below, the colorization system is illustrated. Each layer is represented by a column, which are combined *added* horizontally, resulting in the picture at the right hand side. Each component of the layers can be seen as rows, and these are *multiplied*

column-wise in order to bring the result of the image below each column. The texture samples and masks in the figure are actual images used in the game.

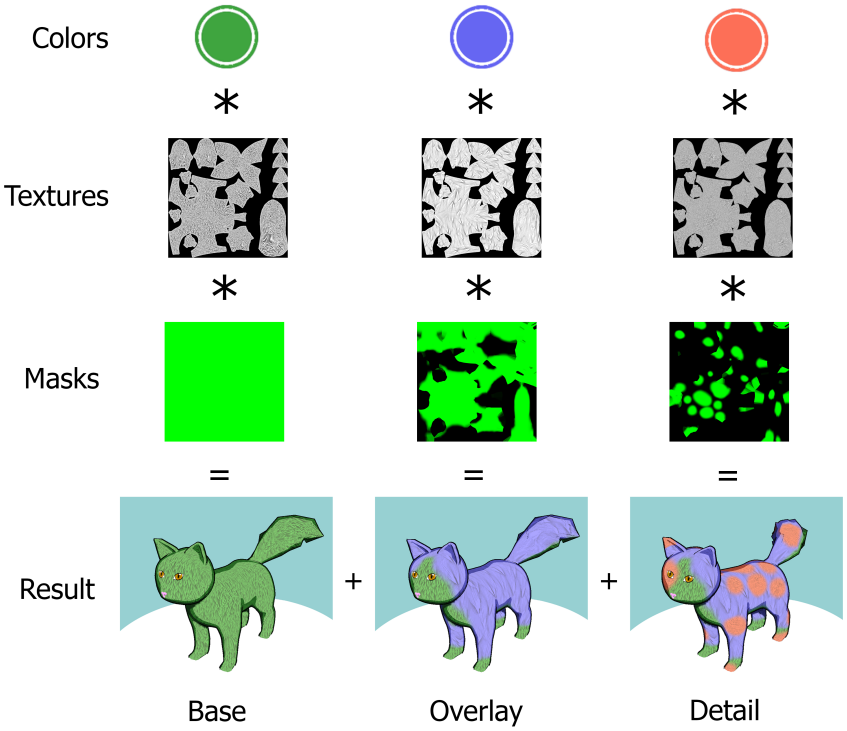


Figure 9: A representation of the pet coloring scheme

In addition to be able to customize the color of the pet when creating it, the user also has the option to change other things. The parts that are interchangeable are: eyes, ears, tail, whiskers and nose. These can be changed independently of each other and allows for a more varied customization. Some of the features, including eyes, nose and whiskers are changed in texture-space, meaning that a texture is changed on top of a plane that is located just above the surface of the animal. With the help of transparency, it is then possible to change these features without altering the actual 3D model of the animal, and all eyes, for example, share the same texture space. For limbs, however, like ears and tail, it was concluded that models would have to be used instead in order to keep a high graphical quality. The same animation rig is used for all pets, regardless of what specific ears or tail the user picks.

7.1.5 The World Markers

An important part of any AR game featuring a GPS map, is the game world projected onto the map. When the player explores the world, there are objects of different kinds that the player might find. A core concept of Augotchi is the notion of "world markers". World markers are points of interest that the player may interact with, once close to

them. When the world marker is inside the players reach, it may be pressed, in which case something happens. In Augotchi there are nine kinds of markers. These markers are:

- **The bush** - When interacted with, the player will forage and find seeds of varying kinds. These seeds can later be planted at the Ranch when the player returns home. The seeds then grow into produce that the player can feed to the pet, keeping it alive and happy.

- **The pile of rubble** - When the player interacts with the pile of rubble, the player scavenges the rubble and acquires some *building materials*, which is one of the resources in Augotchi. The amount gained is randomized.

- **The treasure trove** - The treasure trove is a rare marker. When the player interacts with the treasure trove, he or she is rewarded with a chance to receive a collectible cosmetic item for the pet. The collectible item granted is random, and if the player already happens to have the cosmetic item, the player is instead rewarded with a relatively large amount of gold as compensation. This system makes new cosmetic items harder to get as more items are unlocked.

- **The quest sign** - The quest sign is where local wild animals of the land post tasks they want done, in exchange for rewards, like currency or items. When interacted with, the player is given a randomly generated quest which appears in the players quest log.

- **The Wrongworld root** - The Wrongworld root is a rare, mysterious item with remarkable powers that are rarely found in the world. When the Wrongworld root is pressed by the player, it simply gives the player a Wrongworld root item. The player may only carry one Wrongworld root at any time, and if the player already has one in his inventory, the marker cannot be found in the world. The Wrongworld root is used by the player in order to revive the pet, should it pass out, consuming the root in the process and allowing more Wrongworld roots to once again appear in the world.

- **Roger** - Roger the Raccoon is the traveling merchant of Augotchi. When the player comes across Roger, he or she may interact with him in order to bring up the shop interface. Here, the player may sell things that he or she does not need, such as excess produce that the player has farmed at the Ranch. Roger also sells useful items like seeds, produce and decorative items for the Ranch. The stock Roger has at any one time is randomized, so his inventory will always be unique whenever the player finds him. This is the place where the player can earn and spend *Augotchi coin* currency.

- **The dungeon** - The dungeon is a dark and dangerous place where treasure is found. When interacted with by the player, he or she is presented with an interface for sending the pet into the dungeon, so that it may retrieve the treasures within.

There is risk of failure, however, depending on how dangerous the dungeon is and how strong the pet is. Dungeon exploration is not instantly executed, and thus the pet will be gone for an amount of time based on the difficulty of the dungeon. But if the pet succeeds, the player is rewarded with a desirable item, experience or currency.

- **The pond** - When interacted with by the player, he or she yields a number of fish. Fish is food, just like the farmed produce, and can thus be fed to the pet. See appendix B for more detail on what types of fish can be caught in the pond.

- **The forest** - When interacted with by the player, he or she forages for wild produce. The list of items that can be found in the forest, as well as the characteristics of them, can be found in appendix B.

7.1.6 Currency

The collection of various things is a common theme in many games. As seen in the co-design workshops, progress is one of the core concepts that potential users could find important, and different types of currencies allows the player to reach long term goals in many small steps, for example, by saving money in order to later buy one expensive item. In Augotchi there are two currencies. The currencies are used for entirely different purposes, but the means of acquiring both currencies remain almost the same. The two currencies of Augotchi are:

- **Augotchi coins**
  The Augotchi coin is one of the two currencies of Augotchi. Depicted by a gold coin (see figure 10 below), this currency is used to trade with Roger. The coins can be gathered in many ways, including questing, leveling up, when getting a duplicate cosmetic item, selling things or produce to Roger, or as a reward from dungeon exploration. The Augotchi coins may be spent at Roger's shop in exchange for goods, such as seeds, produce, food or decorations for the player's Ranch.

- **Building materials**
  The second currency of Augotchi is building materials. Building materials, depicted as an assortment of resources (see figure 11 below), may also be collected in several ways. The easiest way to get more building materials is to walk around the world and look for "piles of rubble". Each pile of rubble the player inspects grants him between five and twenty building materials in increments of five. The building materials can also be collected in many other ways, including leveling up, completing quests and as a reward for dungeon exploration. The building materials can be used in a variety of ways. The most important thing to use building materials for is building the Ranch, which costs the player 100 building materials. The building materials are also used for moving the Ranch to a new place, which costs 500 building materials. More than that, building materials are used for placing decoration

items at the Ranch. However, when using building materials for decoration, they are refunded once the decoration item is removed. The cost of placing decoration items at the Ranch varies, depending on the item, ranging from 250 for the cheapest items to 25000 for the most exclusive item in the game. In addition, building materials are the objective of the quest "Piling up", in which the player is asked to collect a certain amount of building materials.

Figure 10: Augotchi coin icon

Figure 11: Building material icon

7.1.7 Pet Accessories

Two of the most important aspects of a location-based AR game (according to co-design workshop results) is customization and progress. Thus, the team decided something was needed in addition to the pet customization, in order to further increase the customizability of the pet. Considering the success of cosmetic items, such as hats, in many other games, the team decided to implement hats and facial appearances in Augotchi.

Hats come in many different shapes and colors. Hats refer to any item that the pet wears on its head, and are not necessarily clothing related. They range from horns, to hair, and actual hats. Facial decorations come in many forms as well, such as clown noses, moustaches, beards, glasses and teeth. Any hat can be combined with any facial decor item, resulting in a variety of combinations. Adding that to the huge number of unique pet appearances, this gives the player substantial customization options.

Cosmetic items are easy to come by in the beginning of the game, in order to grant the players some options to choose from. At the same time, it should be hard, or even impossible, to gather all of them. Thus, the team came up with a system which grants the player a chance to receive any specific hat or facial feature, whenever one is acquired. If the player does not have it unlocked already, the player permanently unlocks it. However, if the player already has it unlocked, a monetary reward is granted instead. This gives the player a high chance of unlocking new hats and facial features early on, when the player does not have many unlocked already. However, as the player unlocks more items, the chance of getting a new appearance dwindles.

7.1.8 Quests

Quests are gained by taking a quest marker in the world. Each time this event occurs, a new quest is generated and added to the player's quest log. The quest log contains all active quests, the progress achieved so far on each quest and the quest rewards. There are eight different quest types in Aiugotchi, some of which have already been mentioned:

- Piling up! - Gather an amount of building materials.
- Coinspiration theory! - Gather an amount of coins.
- Gluttony! - Feed the pet a number of times.
- Need for seed! - Gather a number of seeds.
- Leveling up! - Gain a number of experience points.
- Walk in the park! - Take a number of steps.
- Farm plot hot shot! - Harvest a number of crops.
- Mark my world! - Collect a number of map markers.

Furthermore, there are four different reward types:

- Building materials - Amount rewarded is based on the difficulty of the quest.
- Coins - Amount rewarded is based on the difficulty of the quest.
- Experience points - Amount rewarded is based on the difficulty of the quest.
- Garden decoration - One random common item is rewarded, regardless of quest difficulty.

Whenever a new quest is generated, a quest type, which is not already in the quest log, is randomly selected, and then the quest reward is randomly generated. Difficult quests are those with higher requirements, for example, feeding the pet a lot of times or taking a lot of steps. Finally, the reward is calculated based on the reward type and the difficulty of the quest.

When a quest is completed, a fanfare is played, and a button appears on the quest's item within the quest log. When this button is pressed, the player receives the reward, and the quest is removed from the game, leaving a spot open for a new quest. The player can have up to five active quests at the same time.

7.1.9 The Ranch

When the game starts the pet has no home, and the player is asked to gather 100 building materials in order to construct the Ranch. The player's Ranch will be built at the location of the player, and is geo-positionally locked. This means that the player should pick the spot carefully, as moving the Ranch costs a lot of building materials (500). In addition, all the crops that the player has planted are destroyed when moving the ranch, while all placed decorations are refunded and returned to the player's inventory.

Figure 12: Depiction of the in-game Ranch and garden of Augotchi

The Ranch has several purposes. The most important aspect of the ranch is the garden, in which the player may plant seeds in order to produce crops. There are a total of twelve plantable crops in Augotchi, most of which can be fed to the pet to replenish it and make it happy.

The second major purpose of the Ranch is to provide the player with a home. This home is meant to be something that the player can cherish, and thus a large part of the Ranch comes down to decorating it with different props. Each prop, when placed, requires a fixed amount of building materials, which will be returned to the player if he or she removes the decoration. There are 29 unique decoration models in total, and most of them even have different styles, allowing the player a wide array of objects that can be used in order to decorate the garden.

7.1.10 Produce

One of the most important features of Augotchi is the ability to plant and harvest crops. The primary purpose of farming is to acquire food that can be fed to the pet, in order to prevent it from passing out. A secondary reason for harvesting a lot of crops is to sell them to the wandering merchant, Roger. One farmable crop, the gold nugget bush, is farmed solely for this reason.

In order to farm, the player must first build the ranch. After the construction of the ranch, the player has a garden in which seeds may be planted. The player receives seeds by either foraging bushes on the world map, or buying them from Roger. Seeds are planted by navigating to the "seed"-tab of the player inventory and pressing a seed to plant. When selected, the player is returned to the world where the seed can be placed within the garden area of the Ranch. Note that seeds cannot be placed on top of the house, the fence surrounding the garden or on top of already planted seeds. When tapping an unoccupied space in the garden, a patch of soil is formed, called a farm plot. With the farm plot comes a timer which allows the player to see the remaining time before the crop may be harvested. Appendix B showcases all the seeds and the crops they produce.

When a seed is fully grown, the timer changes to a green button, indicating to the player that the crop is fully grown and ready to be harvested. When tapping the farm plot, it will be removed and some crops are put into the players inventory. These crops may then be fed to the pet in the pet home scene, or sold to Roger.

7.1.11 Garden Decorations

One of the major features of Augotchi is the ranch. The player may gain decoration objects for the ranch by completing quests and dungeons, or by gathering Augotchi coins in order to buy them from Roger. Of the 29 unique available decoration items, ten cannot be granted as a quest reward, nor be found in Roger's shop, which means the player needs to send the pet into dungeons in order to get a hold of these items.

Garden decorations cost building materials when placed. This is the primary use of building materials, other than the first 100 for building the ranch, and the occasional 500 for moving it. The building materials do not get consumed when placing garden decorations, since the building materials are refunded when the decorations are removed by the player.

Once the player has gathered a decorative item and the required amount of building materials, the item may be placed in the garden. Decorative items are placed by opening up the inventory, navigating to the "Decorations" tab and pressing the item that should be placed. When the item is selected, the interface for placing the item will show up, granting the player a set of tools which allows him or her to rotate, scale and move the decoration, as well as choosing the style of the item (some decorations have more than

one appearance variation). The system for decorating the garden was influenced by a similar system for placing decoration items in the game "Planet Coaster" [116].

Appendix B features a list of all the 29 decoration items available in Augotchi.

7.1.12 Dungeon Exploration

Dungeon Exploration is the only way to attain the most rare items in Augotchi. Dungeons are rare markers that, when pressed, display a dialog for the player. This dialog contains a number of values relevant to the player, concerning the dungeon.

- Dungeon name - The dungeon name is randomly generated based on the difficulty rating of the dungeon. Difficult dungeons tend to have grim names, such as the "Chamber of Torment", while less difficult dungeons tend to have cheerful names like "Road to Happiness".

- Difficulty rating - The value of the difficulty of the dungeon. This difficulty reaches from 125 to 2500 in increments of 125, resulting in twenty possible difficulty ratings.

- Stat weights - Each dungeon has different stat weight values, which determine how important strength, intelligence and agility are for successfully exploring the dungeon. For example, if the pet has 1000 strength, and the strength weight of the dungeon is 40%, then the pet's strength contributes with 400 to the pet's total power for that dungeon. The stat weights always amount to 100% in total.

- Success rate - This is the chance that the pet has to succeed, and it is the most important value displayed in the dialog. The success rate is calculated based on a mathematical formula which takes the total pet power and dungeon difficulty rating into account. The formula was designed to give the pet at least a 10% chance of success. Furthermore, it was designed so that a pet with a power equal to the dungeon difficulty would have about a 50% chance of succeeding. Finally, the formula does not allow the chance to become 100% or higher. The function looks as follows:

$$S_r = 1 - \frac{0.9}{1 + \frac{P_p}{D_r}}$$

  Where P_p is the total pet power after weights have been applied, D_r is the Difficulty rating of the dungeon and S_r is the resulting success chance.

- Reward - The reward of exploring the dungeon successfully is generated in the same way as rewards for quests are generated. However, the reward amounts are much higher for dungeons. There are also garden decoration items which may only be

attained through exploring dungeons, and these items are more common in higher difficulty dungeons.

- Time - A dungeon takes time to explore. Once the pet has been sent into the dungeon, it disappears and it cannot be fed. However, it also does not deteriorate while inside the dungeon. The more difficult a dungeon is, the longer time it takes to complete. In general, a dungeon takes several hours for the pet to explore.

When a dungeon is completed, a dialog is displayed for the player which states that the pet has returned from the dungeon, and whether the endeavour was successful or not. The pet is then ready to be sent into another dungeon, as it can only be sent into one dungeon at a time.

7.2 Evaluation Session Results

The evaluation session was designed to result in a brief evaluation of the different features of the application. It is important to note that the group of people invited to this third session were friends of ours. Hence, in order to avoid biased answers, the features were primarily evaluated in comparison to each other.

For a more complete overview on how the sections were carried out, see the section on evaluation sessions in the process chapter (6.5.1 and 6.7.5 respecitvely). In short, the Sessions were carried out in four blocks (with one block covering a specific area of the application) and every block in turn consisting of two parts, a spin on the NASA TLX [58] method (with some altered parameters to more closely fit the information sought) and an interview part where some qualitative data could be extracted [117].

7.2.1 TLX form results

Figure 7.2.1 shows the *mean* data of the TLX forms [58].

Mean	Mental	Physical	Temporal	Performance	Effort	Frustration	Enjoyment	Creative Freedom
Pet Creation	6.25		3.25	4.5	8	9.5	15.5	12.75
Tamagotchi	11.5	13	12.75	9	11.25	13	10	
AR-World Markers	2.75	10.75	9.25	10	10	12.25	13.75	
AR-World Garden	7	8	8	11.5	9.5	10.25	13	11.75
WoW	10		8.75	9	9	5	13.5	13
TES V: Skyrim	10		3	10.33	13	6	14.66	11.66

The parameters of each TLX are represented by the columns, and the different topics make up the rows. The first three columns represent Mental-, Physical-, and Temporal

demand respectively. A black cell indicates that a specific parameter was not included in the TLX. The figure is also color coded, where the red cells indicate the worst score for that parameter, and the green indicate the most positive scores. The parameters were graded from one to twenty, one referring to "Very Low" and twenty being "Very High". So, for example, a "Very High" in "Physical demand" is considered bad while the same score in "Enjoyment" is good. The exception to this is the Performance, ranging from a one being "Perfect" and a twenty being "Failure", making a low score better. Note also that the World of Warcraft [111] and The Elder scrolls V: Skyrim [112] character creation TLX's were included here, but only as an reference at the bottom (colored gray) and was not taken into the highest and lowest value highlighting.

The most significant finding of the TLX forms was that the topic with the lowest scores, across the board, was the Tamagotchi aspect of the game, and the one getting the highest scores was the Pet Creation.

7.2.2 Interview results

The second part of the evaluation sessions was an interview. In this interview, the participants were asked questions relating to the topic for they had just answered a TLX form. The topic was brought up and discussed, and here are the results from the interview part of the sessions:

Pet Creation

- *Do you feel your pet is unique to you? Does its appearance matter?*

  The answers acquired regarding this were spread, ranging from participants agreeing that the pet felt unique to them and that the appearance of their pet was highly important, to some participant who thought that the pet creation was not enough but that it did not matter what the pet looked like.

- *Is there anything you would like to see that is not currently in?*

  Two areas of discussion arose due to this question. The first being the ability to scale individual body parts, or even better, to choose the body form of the pet, enabling the user to make pets resembling different animals (for example a rabbit or a dog, both having very different body form than the cat inspired body which is in Augotchi at the moment). The second large point made was the ability to have different personalities of the pets, and changing the animations and posture of the pet accordingly.

- *Randomize vs. Create*

  This topic arose during the previous co-design workshops, in which the participants

discussed if the player should be able to freely create their pet at the start of the game, or if they would want to be assigned a random pet with a random appearance. During the interviews, we asked the participants about this topic, and they all expressed that they were happy that they got to design a pet of their own and that a fully random pet could be bad. However, it was mentioned that a randomized pet would be fine, but only if it could be modified afterwards.

- *General discussion*

  During general conversation with the participants the players seemed quite happy with how their pet looked, and that in general, changing the pet itself after creation would hurt consistency, in which case cosmetic items such as clothing would be a better solution.

Tamagotchi aspect

- *What do you feel about the combination of Tamagotchi and AR features in general?*

  Regarding this topic, three of the participants were positive, one even going as far as to say that it is the future of this kind of mobile games. One however was not convinced, and stated that the game would be better of without the AR features.

- *What do you feel about permanent death of the pet, compared to as it is in Augotchi now, compared to having no consequences at all?*

  This was a widely discussed point that culminated in all of the participants stating that permanent death would be too harsh, but that there definitely should be some kind of consequence of letting your pet pass out. One of the participants said following when talking about permanent death (translated from Swedish): "Maybe someone have bonded with their pet". There was also a concern that the consequences should be appropriate with how hard it was to keep the pet alive. Meaning, that if it was hard to keep the pet alive, the consequences for failing should be more forgiving, and vice versa.

- *Mini-games with the pet, would it help? Any ideas?*

  Here the participants were evenly split. One side thought that mini-games would be a waste of time, and would not add anything to the application, maybe even making it worse. The other side thought that it would be fun to have more activities to do with your pet, or that your pet could help out with certain, like fishing or gardening. Several of the participants viewed perfect farm plot placement around the house as a mini-game. The garden was designed to fit six plots, but one player claimed that, although quite tough, it was possible to fit in nine.

- *General discussion*

Some general discussion arose regarding the Tamagotchi topic as well. One point several talked about was food, and that the food system at the moment was a bit overwhelming and uninformative. In Augotchi, different foods grant different bonuses (see Section 7.1.10) and that is not presented to the user at all inside the application. Someone even thought that there were too many different food types present in the game. Also, a great find was that the "pet" function had been accidentally removed. In earlier versions of the game you could "pet" the pet in the home screen, which gave it a small bit of happiness and made it play an animation. When reworking a related software system, the ability to pet the pet was also lost, and this was something that the players reacted relatively strongly to.

AR-World:Markers

- *Markers: Static vs. Dynamic*

  This discussion revolved around what the pros and cons were in regards to having static markers in the world (by using real world landmarks, as in Pokémon GO [3]), or generating them dynamically, as was the case in Augotchi at the moment. All the participants expressed that they liked the dynamic system better, especially the two participants who lived in rural areas, although both systems of course had their pros and cons. Several of the participants talked about the idea of having some kind of mixed system where some markers would be static and the more general markers being dynamic.

- *Markers: Hidden vs. Visible*

  In Augotchi, The world markers were visible from a long range at first, and was changed to being hidden until the player approaches them. Almost all of the participants argued that they liked the earlier system of visible markers better. Stating that the surprises of the second system was not worth the effort and risk of walking around without finding anything at all. This could, however, also be an issue with how densely the markers are generated on the map. Just like the previous topic, pros and cons were found in both systems.

- *Enjoyment per effort, is it worth it?*

  This question was asked in order to evaluate whether the effort put in by the player resulted in to many or to few rewards within the game. One participant thought that it was adequate, the other three however stated that they thought the effort level was too high compared to the rewards received. One issue discussed was the difference between playing the game on foot and playing the game while riding a car/tram/bus. While riding a vehicle, the reward/effort was almost too high, compared to when playing the game whilst walking, in which it was perceived as too low, and also, too random.

- *Any thoughts on clothes and unlocking them?*

The general idea regarding clothing seems to be that it works as it is. One comment was that more clothing may have been good (someone asked for capes, for example) and that the clothing was a bit to quickly unlocked in the very beginning. Furthermore, the clothing should probably be possible to unlock in more ways than just through finding treasure markers or leveling up.

- *Any thoughts on Questing?*

  The general feedback regarding questing was that the quests were worth fulfilling, but that the tasks were uninspiring and boring. Several of the participants expressed that they mostly just took quests without reading what they were supposed to do, and just let them finish in the background while playing the rest of the game, paying them no mind. The participants agreed that money is the best quest reward while building materials is the most boring reward.

- *Any thoughts on Dungeoneering?*

  The feedback on dungeoneering was quite slim in comparison to the rest. The reason being that the feature was somewhat new and that the participants had not enough experience testing it. The most notable feedback was that dungeons should impact the pet in some way, both when it succeeds and when it fails.

- *General discussion*

  The participant who had played the game the most ran into problems with getting too much building materials, and had stockpiled tens of thousands. While this is just one incident, it might indicate that the economy of the game breaks after a while, and that more systems that drain building materials need to be put in place.

AR-World: Garden

- *Food system version one compared to version two*

  The comparison here is between the new system of finding seeds, planting seeds and harvesting produce, compared to the older system of just pressing a food marker and receiving food in an instant. The participants responded in unison that the new system was a lot more rewarding. Someone stated that they found the large variety of crops pleasing, and some wanted static spots for planting the seeds around the house, instead of dynamically planting them anywhere within the garden.

- *Decorating the garden: Is it fun?*

  The participants liked the idea of decorating the ranch, but they also wanted to get the very most they could out of their ranch in terms of efficiency, and thus did not want to give up precious planting area for decorations. Some stated that this might be solved in just increasing the area of the ranch or by having special decoration

areas, even if that limited customization somewhat.

- *The Augotchi economy: Does it work?*

  The economy in Augotchi was perceived by the interviewees as clunky and not working as intended in the games present state. The players seem to rather bunker up on the excess food rather than selling it to Roger, the shop. As the players did not sell produce, they would not receive enough coins to get an economy going. Some stated that the shop is rather unnecessary, and that they did not see the value in it. At the same time, some seemed to like Roger and stated that he must be left in the game. In the end, the opinions varied to a great extent.

- *General discussion*

  One specific comment was that, in a pinch, the player should be able to feed their pet with the seeds of crops in order to keep the pet from passing out. Another statement regarding the game in general was that it was hard to know that gold nuggets and truffles were only for selling to Roger, further pointing towards the problems of not having an informative UI explaining the use of specific items.

7.3 Quantitative data analysis

During the early phases of the project, a system was set up which stored each player's progress in a database for later evaluation. While the system was neglected along the way, due to a shortage of testers, some data points remained relevant throughout, and some results regarding these data points will be presented in this section.

During the project, Augotchi was downloaded and run on 74 different devices. Some of these devices are devices used during development, however, which means not all of them are relevant. 47 user accounts were used in order to download the application via Google Play, which is the number that will be considered the total number. At the end of the project, 17 still had it installed on their devices.

Out of the 47 players that downloaded the game via Google Play, only 20 actually played the game. 27 out of the 47 users that started the application and created a pet never reached level 2, which implies that they created the pet and then never started the application again. When subtracting the two team members and the 8 participants of the co-design workshops, this leaves 10 unidentified users who downloaded the game and actually played it, and a potential 37 people who downloaded the application due to the online recruitment effort.

In total, Augotchi has been actively played for about 49 hours. Actively playing the game means that the game was open and in the foreground of the device. This means that each player played for about one hour on average. However, the 11 players who started the

application 10 times or more played 44.6 out of these 49 hours. Furthermore, 35 of the 49 hours were played by the five most active players. Out of these five, the player with the least time had played about 4.45 hours, and the top Augotchi player played a total of 9 hours. The 35 hours of the top 5 players were played in 641 separate sessions, each which, on average, lasted for around 3 minutes and 20 seconds. The record for keeping the pet alive was 37.5 days. For the top 5 players, the average record for keeping the pet alive was 28.4 days. For the 11 most active players, the average record was just over 16 days.

8 Discussion

In the discussion chapter, we share our thoughts and reflections regarding the thesis work and the Augotchi prototype. The chapter is divided into five sections, each related to a specific topic. These topics are the process, the results, the project in general, generalizability and future work.

8.1 Process Discussion

The process discussion will mainly revolve around three main topics: Prototype development, co-design workshops and tester acquisition. The development and co-design workshop processes have been considered successful in many regards, and these sections will point out what practices has worked better or worse. Tester acquisition has been a major issue throughout the entire project, which makes its discussion section more analytic, since it discusses what was planned but never happened, rather than what was actually done.

8.1.1 Prototype development

The development of Augotchi was deemed successful in the sense that more was produced than was initially anticipated during planning. One example of this was the MVP development process, which was done in half of its scheduled time. Throughout development, no iterations missed the planned deadline. Even though the game did not awake the interest of the people it was presented to, an issue for which there might be a number of reasons, Augotchi is a bigger game in terms of content and features than we had imagined at the start of the thesis.

There are a number of reasons to why the development process never experienced any major disturbances. The most significant reason being constant communication and the establishment of a common vision of the results of each iteration. Careful planning and thorough discussion prior to any implementation was required in order to achieve a smooth and productive work flow. It was also important that both students realistically evaluated the amount of time that certain work tasks would require. Both students always worked side by side in the same space, which made it possible to communicate effortlessly and immediately whenever any questions arose. Furthermore, the software solutions chosen for developing the prototype, as presented in Section 6.2.2, proved to be useful, stable and sufficient.

As stated, Augotchi is more developed than initially anticipated, since it is almost a finished game, rather than just a vertical slice of a finished game. However, this is not necessarily the optimal result. Although a more developed prototype is better than a less developed one, this does not mean that the prototype's level of development coincides with

the time that should optimally be dedicated to its development. The thesis was originally aimed at exploring human-pet relationships in AR games, but due to a lack of willing testers the aim continuously shifted towards prototype development and game design. In general, when sending out a new wave of testing invitations, while waiting for answers, we decided to keep developing the prototype in order to do utilize the available time. This meant that more time was spent on development than optimal. Preferably, testers would be found early in the development process, in which case Augotchi would probably reach a state that resembles version 0.5, without the additional content, dungeoneering system or the garden decoration system featured in Versions 0.6 and 0.7.

Even though the development process had to be shaped in this way considerations were always made when implementing new features regarding the goals of the thesis and the overall game theme of taking care of a virtual pet. The pet creation system, the pet visuals and the pet's animations were created due to the theory regarding character likeability [29], emotional feedback [30] and Mori's uncanny valley [43], as well as convincing results from the first co-design workshop. Effort were therefor put into making the pet feel more lifelike by having it respond to the interactions of the player, as well as making it highly customizable in order to make it appeal more to every individual. Making the pet walk around on the world map and follow the player, creating animations for when the pet was fed, and having the pet appear differently depending on its current state, are some examples of additions to the game that were entirely pet related and which did not directly affect game play.

All game play features also had specific goals in mind, which were established at the start of each iteration. The goal of farming was to make the player feel like they provided for their pet in a more meaningful manner, but also to make the world more interesting to explore, since the various seeds for the crops were gathered there. This ties into Bartsch Viehoff's theory on game enjoyment, in which challenge and the exploration of virtual worlds are listed as two major components [27]. The goal of dungeon exploration and the garden decoration system was to make the pet feel more useful to the player, which is one of the three critical factors of character likability listed by Coulson et al. [33]. By making the pet able to retrieve valuable items for the player, the hypothesis was that the player would appreciate it more. So even though the overall goal of the project continuously changed, we tried to stay true to the initial intents by building the prototype on what had already been found in theory, formal game analysis and co-design design workshops.

8.1.2 Co-Design & Evaluation

To hold a co-design workshop prior to development was a decision made early on due to concerns regarding the validity of some of the ideas that we already had produced during research. One example of such an idea was pet creation, a feature which was thought to be a valuable addition to the game, but which was also presumed to be a time consuming one. The first co-design workshop was valuable in confirming and refuting our own ideas, but it was also effective at generating new ideas that had not been thought of

before.

The participants of the co-design workshops were our friends and coworkers who volunteered despite a lack of any compensation. In order to make their time worthwhile, it was decided to make the workshops fun and engaging as the primary goal, with valuable results coming in a close second. This meant that some results turned out more useful than others, but in general the less useful ideas often generated the most laughs, which helped maintain the enthusiasm of the participants throughout the long sessions. It was difficult to choose which brainstorming techniques to use, as the ones presented in Section 4.1.3 are just a handful of all the techniques, described by Miller [51], that were considered for the workshops. The desired end result and the entertainment value of the activity both had to be taken into account and evaluated before reaching a conclusion. The end result was deemed successful, as the generated content aided us in making future decisions. The participants also seemed to have a good time, which was reflected by the fact that everyone agreed to take part in the second workshop. The process and results of the first co-design workshop are described in Sections 6.5.1 and 6.5.2 respectively.

Three out of eight participants of the co-design workshops were game developers who also worked at Far North Entertainment. These participants had no previous experience with the kind of structured and planned brainstorming rounds that they partook in for Augotchi. In subsequent discussions with said participants, they expressed a new-found enthusiasm for the process and the potential value it generated, with one stating that such ideation should preferably be part of any game development project. The exercise was also viewed as a potential team-building activity, since it required significant amounts of collaboration and communication.

The second co-design workshop was not as successful as the first. The main reason for this was probably that the second workshop was significantly more focused, and was designed with a specific goal in mind. The difference between generating random ideas connected to an overarching theme, and generating a concept within a specific context and with a specific goal, was remarkable. The participants did not express the same level of enthusiasm during the second workshop in comparison to the first, and the creative output was also lowered (Participants ran out of ideas earlier). The second workshop was not designed to be a fun activity to the same degree as the first. Arguably, conceptualization is inherently more constrained and less flexible than ideation, which leaves less room for out-of-the-box thinking. The second co-design workshop was not a failure by any means though, as it generated valuable results, but it could definitely have been more engaging. The process and results of the second co-design workshop are described in Sections 6.7.5 and 6.7.5 respectively.

One finding from the evaluation was particularly interesting; namely the discontent expressed regarding a feature that was no longer present in the game. When the pet was fed in earlier versions of Augotchi, an animation was played based on the food that it was given. This was also true for when the pet was petted by the player, in which case it played an animation designed to make it look cheerful. When the old food system was reworked in version 0.5 the old animations were also removed, but as an unintended side

effect, the petting feature stopped working as well. Discussions surrounding this very specific incident would occupy a disproportionate part of the evaluation. The interviewees were concerned that this feature was gone, as it was the main direct interaction with the pet, apart from feeding it. This result alone lead us to reconsider the focus of the development which had taken place previously, since such a small simple feature caused a major response when gone. If the entire focus of the project would have been to design the pet itself, and less about game activities, the basic Tamagotchi features could perhaps be sufficient in terms of game play mechanics.

This insight was not gained until after the prototype was done. Throughout the project, a major concern we had was that the game was boring. The go-to explanation for this was always that the game had to little progression, too few activities or lacked content. Never at the start of later iterations did we consider focusing on creating more simple interactions with the pet, similar to the petting, or add additional behaviour and animations to it. In a sense, the location-based AR part of the project pushed development in this direction, since the GPS map would be pointless without game play related to it. However, despite this issue, maybe one or two iterations should have been fully dedicated to the pet itself, and perhaps such efforts would have been reflected in the TLX scores associated with the Tamagotchi aspect of the game. The results of the evaluation session are presented in Section 7.2

Since only one external individual responded positively to participating in the testing of Augotchi, the planned user testing was never initiated. This has been a major concern for the duration of the project, since it meant that no conclusive data would be gathered at all during the thesis work. The decision was made to ask some of the participants of the previous workshops if they would like to participate in an evaluation session as well. In order to minimize bias, the other employees at Far North Entertainment were not invited, and the ones who did get an invite were also the ones who had regularly played the game. Still, they were our friends, which meant that evaluating isolated features, or comparing Augotchi to other games, would not be reliable. Instead, comparisons would be made between features within the game, and changes that had taken place during certain iterations would be evaluated. The idea was that, when comparing two features both developed by us, the interviewees could not be biased towards one or the other, at least not based on our personal relationships. A major issue still persisted however, namely that the sample space was to small to really draw any substantial conclusions. In the end, it was deemed the best solution, given the limited resources available. The evaluation process is described in Section 6.8

8.1.3 Tester Acquisition

As stated several times, acquiring testers for Augotchi was a major issue throughout the project. Since not many responses were gained at all, it is difficult to pinpoint exactly what went wrong. The communication channels used, the way the project was presented, the nature of the testing environment and limited exposure to the various posts could

all be possible reasons to why so few connections were made with people not previously involved in the project.

Early on it was decided that online forums would be the main channel for recruitment, specifically Reddit and certain local Facebook groups. Reddit would be used to find testers on an international level, who would play the game, fill the database with automatically gathered data and eventually participate in online interviews. After posting the quick surveys on the Pokémon GO and Ingress Reddit threads, both receiving thousands of responses, we were optimistic that at least a handful of people would like to be involved in the project. However, this was not the case at all. The conversion rate from the surveys to downloads of the game was essentially zero. Gaining people's attention was easy when it was related to their already present interests, but funneling said attention into a separate, yet related, domain proved not so easy. Perhaps the recruitment posts were boring, perhaps the communities were not interested in the concept or maybe they were not inclined to take part in a project of this nature at all. We had a preconceived notion that asking for help with a thesis project would make it easier to engage people, but this could not be confirmed.

A second attempt was made, where a video was created and shared instead, showing some footage from the game. We hoped that this new way of presenting the game would make it more interesting, but the response was lacking.

The Facebook recruitment was perhaps the most important endeavour, since the individuals recruited from this platform would be part of the focus group, or groups, that would yield the qualitative evaluation data. The posts were formal, presenting ourselves, the origin and goals of the project, as well as a brief description of the game prototype and what participating would entail. Yet again, the responses were few, and only one person directly expressed a desire to participate. Apart from the reasons already mentioned in regards to the Reddit recruitment efforts, being part of the Augotchi focus group would require substantial effort from the participants. Not only would they have to spend their time playing the game, which also requires physical exercise, but they would also have to attend evaluation meetings during the spring. This was considered a fairly high bar by us internally, and after failing to just have people download and try the game, hopes were low. The same issues arose when trying to recruit young adults from upper secondary schools.

One important issue, that could very well explain all the difficulties related to tester acquisition for Augotchi, is compensation. If the testers were to be compensated monetarily for their time, it would perhaps be easier to find participants. Furthermore, in a project like Augotchi, the end results do not directly lead to any societal value, such as potentially improved health care or education for children. This means that there is no emotional compensation either. The participants would not have any reason to feel like they were contributing to something important, other than helping a couple of students out. In hindsight, maybe the emotional engagement and pet-relationship research should have been emphasized more during recruitment, and maybe the thesis work should have had a more societal goal. Another angle could be to focus on the health benefits of AR

game play, due to the physical exercise involved. In any case, trying to recruit people to participate in a project, without being able to offer any kind of relevant compensation, seems to be a difficult task. In hindsight, considerably more time should have been spent investigating channels of recruitment, as well as how to use them.

8.2 Result Discussion

In this section the results gained during the project and the different aspects of it are discussed. Topics include are the research done beforehand and how that has impacted the development of the game, a discussion on the features implemented, and lastly the data from the evaluation session.

8.2.1 Research

At the start of the Augotchi project, the focus was severely different than it was in its latter stages. This meant that some of the theory that was researched during the planning of the project became obsolete, and some theory had to be researched during the project or even in the latter stages of the project. While this is something that might simply happen in projects like this, the optimal outcome would not require any rewriting of the theory section.

Early on, the focus of the project was the emotional engagement of the player in relation to the virtual pet. What this meant was that the topic of emotional engagement was researched in depth. During the middle of the project, as mentioned previously, the focus changed. The focus of the project continuously shifted towards game design and prototype development as it became clearer that no testers would be recruited. Thus some new areas of theory had to be researched. Some of the theory on emotional engagement was left out and replaced with a section which focused specifically on location-based AR and how it impacts the development, what effects it has on the player, and what effect it potentially has on society. The main takeaway from Section 3.1 is the health benefits of such games, which inherently makes playing the game more valuable for the player. If Augotchi is turned into a commercial product, the theory surrounding player safety, as well as ethical dilemmas of monetizing the game, will become more relevant.

The research on relationships with virtual companions was something that, even after the shift in focus, stayed highly relevant. There were clearly some similarities between the anthropomorphism of objects [39] and some of the findings of the evaluation session. The research done surrounding the graphical appearance of the pet, especially in relation to Mori's uncanny valley graph [1], were also important when designing the pet. For example, according to the authors that were cited regarding the uncanny valley, the valley could be avoided in one of two ways; Decreasing realism, or increasing realism. There were not enough resources to avoid the valley by increasing realism, so instead it was decreased, resulting in the rather cartoon looking environment and pet that is in Augotchi at this

point. According to the feedback from the evaluation session participants, the appearance of the pet is rather likable, which could suggest that the valley was successfully avoided. However, the possible bias of the participants, as well as the small sample size, makes it hard to draw any conclusions.

In addition to researching theory on relevant topics, a formal game analysis, a method described by Lankoski & Björk [48], was carried out, in which similar games to Augotchi were analyzed. More specifically, the games included were "Ingress" and "Pokémon GO", both developed by the company Niantic Inc. In these game analyses, some patterns were found that both games shared, while some only appeared in one of them. Several of the identified patterns were implemented in Augotchi as a result of them being part of these related games, but also since the features were independently generated during the co-design workshops. For example, patterns like "Constant character progress" and "Never ending gameplay" were found in both the games that were analyzed, and were later adopted into Augotchi as well. While others, for example "Rewards Collaboration", a pattern that was also found in both the analyzed games, was not implemented. In Section 2.4 and Appendix A the results of the formal game analysis are presented in more detail. It is important to note, however, that the analysis of the two games might not be conclusive, and that perhaps more similar games could be analyzed in order to get a complete picture of the state of location-based AR games. Even though two games is a fairly low number, the data and insights gained from analyzing those two games alone were quite substantial. Furthermore, since the genre is fairly young, not many large games of the genre even exist. Analyzing two games made by the same developer could both be beneficial and counterproductive. On one hand, since they made both games, it would be possible to see what changes they made between the two games, changes that were probably based on their findings and research. On the other hand, Niantic might have drawn conclusions that are not necessarily correct.

8.2.2 Prototype Features

There are a number of different aspects of the Augotchi prototype that could be discussed, walking around, collecting markers, pet care and house decoration being some of them. All of the features have been listed and explained in detail in Section 7.1. In this section the final design of the features are discussed.

One aspect of Augotchi is the GPS map and the objects that the player finds while walking around. This feature is very similar to several other AR games, and it is the core AR principle of Augotchi, since without the GPS integration the game would not be in the AR category. Augotchi's GPS map integration reflected well what was envisioned at the start of the project, namely largely similar to the systems of Ingress and Pokémon GO. The markers on the map were changed several times during the project due to testing and iterative development, and the changes were mostly deemed successful. The markers in the game are similar to those of the random Pokémon a player encounters in Pokémon GO, meaning that the marker will spawn randomly around the player as he

or she approaches them and comes within range of the marker. In the final evaluation session the general feedback regarding the marker changes was positive, although, as mentioned previously, the sample space is small and the participants subject to possible bias. When comparing the markers system to other features of Augotchi, it was ranked somewhere in the middle.

Another core aspect of Augotchi is the pet and the tasks associated with taking care of it. The Tamagotchi aspect of the game, namely taking care of the pet, was measured as the weakest of all the aspects of the game in terms of enjoyment. Based on this information, it could probably use an overhaul, similar to the overhauls of the food system and the marker system. One reason that this turned out to be one of the weaker aspects could be the effort required in taking care of the pet. Maybe a good idea would be to have the pets status decay fast or slow, based on the effort put in by the player. As of now, the decay rate does not take into account the ambition level of the player, which means that players who play a lot could find it boring, and players who do not play regularly find it irritating. While this is pure speculation, an interesting change could be to make the difficulty higher for more active players.

The pet creation was also changed somewhat during development, but not as much as the marker system. The reason for this was that the pet creation system was polished somewhat early on during the project. Furthermore, making changes to the pet creation system would alter the appearance of the pets already created by the few people testing the application, which would hurt consistency. In the evaluation sessions, the pet creation aspect of the game was ranked as the most enjoyable aspect of the game (compared to other features).

The second major aspect of the GPS map is the ranch, which enables the player to sow and harvest food, and which can also be decorated with a variety of decoration items. The ranch and the farming system were concepts generated during the second co-design workshop. The notion that the player could manipulate the game world by dynamically placing objects therein had not been considered before the second workshop. Along with the ranch came the new farming system, which replaced the old way of gathering food for the pet by adding a whole new layer onto it. Making it harder to gather food for the pet is not necessarily beneficial, and there were concerns that it would just make the game more tedious, but it seems that was not the case. All participants of the evaluation session thought that the new system of finding seeds, planting them and then harvesting food was worth the extra time and effort required. The garden decoration aspect was the last feature to be implemented, and was thus not fully explored by all of the evaluation session participants. The ones that did try it out liked it, and one specifically mentioned that it made the pet more useful, since the pet found garden decoration items in dungeons.

Dungeon exploration and questing are the final aspects of Augotchi which were evaluated in the evaluation session. Questing was a feature which was conceived of early during the project. The questing system of Augotchi was inspired by the quest system that had arrived in Pokémon GO shortly before. When the testers were asked about it later, it was met with mixed opinions. The majority of testers said it was a good idea, but uninspiring,

hinting that the system was fine, the way the quests were received was okay and that getting additional rewards for playing the game was nice. However, the quest tasks were quite bland, and a larger variety of more specific tasks would be better in order for the player to not just forget about what quests are active at a given moment. Dungeoneering was similar to garden decoration in that it was not fully explored by the testers before the evaluation session took place, since it was an addition which was introduced in the latest version of Augotchi. The ones that tested it said it was fine as well, ranking it somewhere in the middle of the other features.

8.2.3 Evaluation Data

Most of the results of the evaluation session was discussed in the previous section. This section will briefly discuss the validity of the data.

Originally, a large part of this thesis was planned to consist of gathering qualitative and quantitative data regarding the game play and the player's relation to the virtual pet. Unfortunately, the data that was gathered could not be used in a conclusive way. The evaluation session was held with four participants, which is a small sample size, and furthermore, all participants were friends of ours.

Bias is an issue that has already been touched upon. Since there was a friendship connection between us and the participants, this meant that the data could not be presented as valid feedback regarding the various features, unless the features were only compared to other features we developed. The second issue, as stated earlier, is the sample size of our data. Even if a method, such as described previously, would be utilized in order to draw meaningful comparisons from data corrupted by bias, one should have a larger sample size.

8.3 Project Discussion

During the project, as it became more clear that testers would be hard to recruit, the focus of the thesis had to be shifted. When the project started out, the vision was to develop an application while simultaneously conducting user research regarding how the pet's behaviour and appearance impacted the user's emotional attachment and engagement to said pet. The initial research question of this thesis was as follows:

> What is important when designing for emotional engagement in order to enhance user experience in mobile AR applications?

Without any reliable source of data, this focus question would be impossible to answer, since it depends exclusively on observation of interactions between users and their virtual pets. The focus was therefore shifted towards game design and iterative prototyping instead. This shift and the new research question better fit the work that had already

been carried out throughout the project, while also allowing for more, similar, work to be done. Exploring AR game features surrounding the virtual pet became the new goal of the project, and the research question of the project was changed into:

> What game components are important when designing a virtual pet for mobile AR games?

In the new definition, the users were essentially removed from the focus of the project, although some were retained to give feedback on the features that were implemented. While still being an important part of the project, a major user study was no longer critical to its success.

This outcome was not what we had intended, and the change of the research question was seen as a substantial downgrade. While game design is a topic which both students were highly interested in, the new potential end results of the thesis were perceived as more shallow and less intricate than they would have been if the original vision had been pursued. Furthermore, we wanted to do something different from what we were already comfortable with, which in the case of the thesis initially was to expand our knowledge and expertise within the area of user research. The co-design sessions and the evaluation session were also part of this expansion of knowledge surrounding the practical application of concepts that we encountered during our studies.

We still believe that emotional engagement in relation to a virtual pet is an interesting area worth exploring. There are certainly a lot of possibilities which comes with new technology, be it software applications utilizing VR or AR technology, or even highly advanced robots. The potential of such technology in terms of entertainment, social and societal value is largely unexplored, with location-based AR being a young technology that fairly recently had a major breakthrough with Pokémon GO, and VR which is still struggling to entice the mainstream population.

Creating a concept which combined AR technology with the classic concept of the Tamagotchi proved a difficult task even after the research question changed. Defining the goals of the game, the mechanics related to taking care of the pet and how to make the player care about it, have all been central issues throughout the entire project. At the same time, the problems had to be solved in a manner which made them compatible within the context of AR and the GPS map integration. Even though few conclusions could be drawn during the thesis work, the exploration of the possibilities and constraints of AR, as well as the implications of a virtual companion within such an environment, was valuable in order to understand AR game design in general and virtual companion design in particular.

Another topic of discussion is the target age group of Augotchi. Since the individuals who agreed to participate in the first and second co-design sessions were all aged 24 – 26, it was deemed important that the features based on their ideas would be evaluated by testers approximately the same age. The age span was stretched in order to not make tester recruitment to hard, and was eventually settled at 18 – 30. However, the age group

was discussed at several times during the project and was not by any means easy to determine. For example, Augotchi could be targeted towards children, for which it could also be developed as a tool for practicing responsibility, similar to toy baby dolls or taking care of a real life pet. It could also simply be the case that the concept is better suited for a younger audience in general. On the other hand, when recruiting testers on Reddit, one user pointed out in regards to the eventually settled age group of 18 - 30, that we should not underestimate the middle-aged population as a target group for mobile game development.

One of the reasons for not choosing small children as the target group was a concern over how they would be able to play the game. Not all children have smartphones capable of running Unity applications, and even if they did, a game like Augotchi might be dangerous for a child to play. Especially if said child lives in central Gothenburg. Furthermore, the consent of the parents of the children would have to be sought out, which would lead to an additional administrative burden. At the time, these reasons seemed logical and well-founded, but in hindsight, maybe it was a missed opportunity, since these very reasons could be interesting topics of investigation. We also believe that small children could be easier to recruit than young adults, through elementary schools, which would have solved the biggest issue of the Augotchi project. This belief is founded on the previous experiences that one of us had in a course revolving around the design of technology for children, in which the children who partook in the design activities were both enthusiastic and ambitious.

8.4 Generalizability

The problem with generalizing the results of the Augotchi project is its narrow scope. The previously mentioned focus on emotional engagement and user-pet relationships could perhaps lead to insights which could be useful in a broader sense, and perhaps applied to, for example, human-robot interaction as well. When the scope was limited to AR games in particular, it was substantially narrowed. The researched theory was, however, broader in scope, spanning over more areas than just AR-games. Even though the pet ended up being created for a game for entertainment purposes, it is still reasonable to assume that a well-designed pet increases the retention and entertainment value of the game.

The results of the project and the very limited conclusions that could be draw from the evaluation session could at least give a hint at what works and not in similar games, although not the same kind of games. For example, most of the testers liked the new way of securing food for the pet, which could hint that such a way of gathering items could be more satisfactory than just granting the player the rewards directly with a click. A similar change could theoretically be made to the item gathering systems of Pokémon GO or Ingress, and the feedback gained from the large player base could either strengthen or deny this hypothesis. Furthermore, the findings regarding the markers of the GPS map could also be universal, in particular the notion that the landmark based

markers of Pokémon GO and Ingress makes the games impossible to play in certain areas. Respectively, some of the results regarding the pet and the Tamagotchi aspects of the game might very well apply to similar virtual companion games, even those that lack AR functionality.

8.5 Future Work

The potential for future work based on the work done in this thesis is narrow in scope, but endless in terms of possibilities within the given scope. An AR game can still vary in terms of themes and fundamental game play mechanics. Although it was never conducted in practice, the issue with conducting user research for a game like Augotchi will be discussed, since it is an issue that has been thoroughly discussed between ourselves a number of times during the project.

8.5.1 User Testing in AR

A larger study with a pool of tens, preferably hundreds, of testers would be needed in order to draw solid conclusions regarding specific features and mechanics of Augotchi. While there are AR games on the market which have seen success, not much research was found surrounding the design of AR games in general. Some research was found regarding AR games, but these sources generally spoke of peripheral matters, such as the societal impact of AR games. There seems to be a lot left to explore in regards to how AR games are designed, and maybe there are concepts not yet discovered that would revolutionize the game market in general, and the AR market in particular. After all, Pokémon GO's enormous success might not have solely been due to its excellent game design, but due to its famous brand.

Even if a large tester base could be recruited for the purpose of verifying what works and what does not work in an AR game, there are also questions regarding how such testing would be conducted. In the case of Augotchi, testing was deemed impossible to conduct in an isolated and controlled environment. The main reason for this is the nature of the Tamagotchi game play. Since this core feature requires days, or even weeks, of regular game play to be reasonably evaluated, planned sessions where the developers observe the player as he or she plays the game is not possible. Furthermore, game mechanics that take place in the AR setting require the players to move around in the real world, which means that testing would not be possible to conduct in a confined space. A game which requires the player to break both temporal and physical constraints seems difficult to evaluate reliably even with a large sample size, and there seems to be no previous work done on this topic. Obviously, this is due to the problem being a highly specific one, but it is an interesting problem nonetheless.

8.5.2 Concept Considerations

The core concept of the application as it stands today is an AR Tamagotchi game. This has two core components, the AR concept, with GPS based movement on the real world map, and the Tamagotchi part where the player takes care of the virtual companion. One conclusion that can be drawn from the evaluation data is that all of the participants ranked the Tamagotchi aspect of the game as the weakest. This means that one of the two core components of the game was deemed worse than most of the secondary features as well. There could be several reasons for this, one being that the few testers that partook simply did not enjoy the concept in general, or as mentioned during the project discussion, that the pet was not engaging enough. Another possible reason is that the AR game play might collide with the requirements that a Tamagotchi-like game brings. For example, if a person were to become sick for a number of days, his or her pet could pass out, since that player would not be able to walk around outside in order to gather food for the pet. In order to play Augotchi in a successful manner, the player is forced to take occasional walks. This forced physical effort could perhaps be perceived by the player as tedious and harsh.

If it is the case that the combination of a Tamagotchi and the AR GPS map is inherently flawed, the concept would have to remove either one of them. Rendering the pet in the camera of the phone is another AR technology, that could be used in order to, for example, make the interactions with the pet feel more tangible. If the virtual companion was to be removed, it could possibly be replaced by a role-playing-game-like character, which represents the player on the map, rather than being presented as a separate "being". One would then venture the world as this character, amassing treasures, learning skills and achieving fame in a similar way to how many other role-playing-games work, but with the GPS map as the game world. There are a number of game genres that could potentially be combined with AR technology, the Tamagotchi being just one of them. Since the AR game genre is young, there are potentially such combinations that fit better together than in the case of Augotchi.

8.5.3 Future Evaluation

As mentioned several times in this discussion chapter, user testing has been the major issue during the Augotchi project. Since not much has been done in terms of testing, the evaluation of certain ideas is left open for future investigation.

- The idea behind the dungeon exploration feature was that it would make the pet more useful, which in turn would make the pet more likeable. While this hypothesis was strengthened during evaluation, more information is needed in order to draw conclusions. What kind of rewards should the pet generate? How often should it succeed or fail? Should there be consequences of failing? There are a number of questions that need answers in order for this system to be verified, or rejected, as a means to enhancing the player-pet relationship.

- Farming was introduced in order to make the game more interesting and introduce more choices for the player. In addition, the hypothesis was that it would make feeding the pet feel more rewarding. This assumption was based on the notion that gaining rewards feels more satisfying as more effort is invested in order to reach them. Testing whether the level of complexity of the systems related to taking care of the pet impacts the player's perception of said pet, is another possible topic of investigation.

- GPS map integration has not been proven as an effective means to strengthening the player-pet relationship in any way. The initial idea was for the player to take walks with the pet in order to make it feel better, and this would bring a real-life aspect of pet care into the digital domain. While this is possible in Augotchi, not much can be said regarding its impact on the player-pet relationship. A possibility for future development of Augotchi would be to expand the number of walking mechanics and make them more directly revolve around pet interactions. However, the hypothesis that physically taking walks with the pet has a positive impact on the player-pet relationship must be validated first.

- Based on the results of the first co-design session and the evaluation session, pet customization seems to be a key feature in order to create a personal connection between the player and the pet. This system could be a possible topic for future research, in which it would be iterated over in order to reach perfection. Augotchi's current system allows for trillions of possible combinations, but it has not been established what this means, other than that the chance of two players creating identical pets is extremely low. What changes made to the pet are more or less effective? When does the number of choices in terms of body parts and colors become to many? How important is quality of content in comparison to quantity? All of these questions could be researched and answered, all of which could aid game developers who work on any game featuring a character creation feature, and not just with virtual pets. There could also be different answers to the stated questions, depending on what kind of entity is being customized by any given system.

9 Conclusion

The results of this thesis may not be used to draw any conclusions with certainty, especially in regard to emotional engagement, which was the main topic when the project was initiated. However, after the change of direction of the project, some general answers can be given to the final research question, which reads as follows:

> *What game components are important when designing a virtual pet for mobile AR games?*

This question could be answered in many ways, some of which are presented in this conclusion section. Optimally, the end results of this thesis would consist of a set of guidelines which could aid a game developer when creating a game which is similar to Augotchi. Due to a lack of reliable validation of the various results of this thesis, the conclusions drawn below should be considered as recommendations for consideration, rather than rules.

- **How hard should it be to look after the pet?** The effort level associated with taking care of a virtual pet is essential to how the game is played. The effort level is directly based on the Tamagotchi component of the game, namely the decay rate and replenishment rate of the pet's status values, and all surrounding mechanics have to be balanced with this goal taken into account. If the pet is to easy to take care of, the game becomes boring, since it lacks challenge. If the pet is to hard to take care of, the game becomes tedious, especially since physical effort is required by the player. When designing a new mechanic or feature for a game featuring a virtual pet, or any general game based on the Tamagotchi, the balance of effort required, and value generated, should be taken into account.

- **What makes the game entertaining?** Related to the previous point, the most important aspect of any game is how entertaining it is. Entertainment value in games can be generated in a multitude of ways, not just by implementing well-balanced game mechanics. Apart from interesting activities, there are games that focus on visual appeal, overall atmosphere and competitiveness, to name a few. For Augotchi, activities was the main focus, but it is possible, perhaps even likely, that a focus on the visual appeal of the pet would make Augotchi a better game. Considerations regarding what aspects of a game to focus on should always be made before implementation, so that the effort made generates the highest possible entertainment value.

- **What should the pet be like?** The visual appeal of the pet and how it behaves is of high importance in a game like Augotchi. According to theory, it is essential that the uncanny valley [43] is avoided. Furthermore, the personality of the pet, its animations and its usefulness to the player should also be considered. A pet which is visually appalling, inanimate and without practical usages, will most likely not succeed as a virtual companion. Instead, when designing the companion, strive

towards making it visually pleasing, animated and useful.

The pet customization system seems to be an effective way of ensuring that the visual appeal of the pet is tailored to each specific player. Furthermore, if the player views the virtual pet as unique, it could further strengthen the player's feeling that the pet is, in fact, their pet, since no other identical pet exists. Hence, it is also important that the customization allows for a wide variety of outcomes.

- **What are the implications of AR?** The implications of AR, more specifically a game world based on a GPS map, must also be considered whenever new systems are designed. AR does not seem to inherently enhance game play, but rather the opposite, since in comparison to other games, it requires an additional dimension of effort from the player. If a game feature is not tailored specifically to fit within this context, it will most likely not work well. For example, an AR game may be played while walking, or while taking the bus to work. Optimally, a game feature works well, independent of the mode of transportation that the player chooses. There are a number of other contextual aspects of AR as well, such as weather conditions and if the game is played in an urban or rural area. The number of uncontrollable variables that affect the game increases significantly when it is played in the real world, and these have to be taken into consideration at all times.

References

[1] Wikipedia: Uncanny valley. *Wikipedia: Uncanny valley - Used under fair use.* https://sv.wikipedia.org/wiki/Uncanny_valley, 2017. Accessed: 2018-07-12.

[2] Christopher Grant @chrisgrant Polygon. *Pokémon GO has been downloaded 500 million times.* https://www.polygon.com/pokemon-go/2016/9/7/12836898/pokemon-go-downloads-500-million, 7 sep. 2016. Accessed: 2018-07-12.

[3] The Pokémon Company International Inc. *Pokémon GO Homepage.* https://www.pokemongo.com/en-uk/, 2016. Accessed: 2018-07-12.

[4] Chamary JV. *Why 'Pokémon GO' Is The World's Most Important Game.* https://www.forbes.com/sites/jvchamary/2018/02/10/pokemon-go-science-health-benefits/#91752c23ab0b, 10 feb. 2018. Accessed: 2018-07-12.

[5] Bandai. *Tamagotchi homepage.* http://us.tamagotchifriends.com/, 2018. Accessed: 2018-08-07.

[6] Mival et al. *Personification Technologies: Developing Artificial Companions for Older People*, 2004.

[7] Dafna Lemish Linda Bloch. *Disposable love.* http://journals.sagepub.com.proxy.lib.chalmers.se/doi/pdf/10.1177/14614449922225591, 1999. Accessed: 2018-07-12.

[8] TechTerms. *AR definition.* https://techterms.com/definition/augmented_reality, August 18, 2016. Accessed: 2018-07-12.

[9] RealityTechnologies.com. *MR definition.* http://www.realitytechnologies.com/mixed-reality, 2016. Accessed: 2018-07-12.

[10] Wondershare. *Difference MR vs. AR.* https://filmora.wondershare.com/virtual-reality/difference-between-vr-ar-mr.html, 24 nov. 2017. Accessed: 2018-07-12.

[11] Foundry. *The term MR is dying out.* https://www.foundry.com/industries/virtual-reality/vr-mr-ar-confused, 2018. Accessed: 2018-07-12.

[12] dictionary.com. *VR definition.* http://www.dictionary.com/browse/virtual-reality, 2018. Accessed: 2018-07-12.

[13] R. Behringer R. Azuma, Y. Baillot. *Recent Advancements in Augmented Reality.* http://ieeexplore.ieee.org.proxy.lib.chalmers.se/document/963459/

?part=1, Nov/Dec 2001. Accessed: 2018-07-12.

[14] Cousins S.B. Barton J.J., Shumin Zhai. *Mobile Phones Will Become The Primary Personal Computing Devices*. http://ieeexplore.ieee.org.proxy.lib.chalmers.se/xpls/icp.jsp?arnumber=1691697, August 1, 2005. Accessed: 2018-07-12.

[15] Steve Love. *Understanding mobile human computer interaction, chapter 1*. https://www-sciencedirect-com.proxy.lib.chalmers.se/science/article/pii/B9780750663526500025, 2005. Accessed: 2018-07-12.

[16] Statista. *Number of smartphone users worldwide*. https://www.statista.com/statistics/330695/number-of-smartphone-users-worldwide/, 2018. Accessed: 2018-07-12.

[17] William L. Hosch. *Augmented Reality*. http://academic.eb.com.proxy.lib.chalmers.se/levels/collegiate/article/augmented-reality/476768, 2018. Accessed: 2018-07-12.

[18] Niantic Inc. *Niantic, Inc. Homepage*. https://www.nianticlabs.com/, 2018. Accessed: 2018-07-12.

[19] Niantic Inc. *Ingress Homepage*. https://www.ingress.com/, 2016. Accessed: 2018-07-12.

[20] Julia Cresswell. *Tamagotchi description*. http://www.oxfordreference.com.proxy.lib.chalmers.se/view/10.1093/acref/9780199547920.001.0001/acref-9780199547920-e-2731, 2009. Accessed: 2018-07-12.

[21] Curiopets. *Curiopets Homepage*. https://www.curiopets.com/, 2017. Accessed: 2018-07-12.

[22] World Health Organization. *Global Strategy on Diet, Physical Activity and Health: Physical Activity*. https://www.who.int/dietphysicalactivity/pa/en/, 2019. Accessed: 2019-05-15.

[23] Jean-Philippe Chaput Allana G.LeBlanc. *Pokémon GO: A game changer for the physical inactivity crisis?* https://www-sciencedirect-com.proxy.lib.chalmers.se/science/article/pii/S0091743516303656?_rdoc=1&_fmt=high&_origin=gateway&_docanchor=&md5=b8429449ccfc9c30159a5f9aeaa92ffb, Aug 2017. Accessed: 2018-07-30.

[24] Lisa Jacka & Lachlan Hartley Yee Ruth Potts. *Can we 'Catch 'em All'? An exploration of the nexus between augmented reality games, urban planning and urban design*. https://www-tandfonline-com.proxy.lib.chalmers.se/doi/full/10.1080/13574809.2017.1369873?scroll=top&needAccess=true, 11 sep 2017. Ac-

cessed: 2018-07-30.

[25] Nicola Liberati. *Phenomenology, Pokémon GO, and Other Augmented Reality Games*. https://link-springer-com.proxy.lib.chalmers.se/article/10.1007%2Fs10746-017-9450-8, 07 Nov 2017. Accessed: 2018-07-30.

[26] Rhett Jones. *Study Estimates That Pokémon GO Has Caused More Than 100,000 Traffic Accidents*. https://gizmodo.com/study-estimates-that-pokemon-go-has-caused-more-than-10-18207769083, 27 Nov 2017. Accessed: 2018-07-30.

[27] Reinhold Viehoff Anne Bartsch. *The Use of Media Entertainment and Emotional Gratification*, 2010.

[28] Riva Et al. *Affective Interactions Using Virtual Reality: The Link between Presence and Emotions*, 1 feb. 2007.

[29] Moyer-Gusé. *Toward a Theory of Entertainment Persuasion: Explaining the Persuasive Effects of Entertainment-Education Messages*, 1 aug. 2008.

[30] Woontack Woo Ahyoung Choi, Celso De Melo and Jonathan Gratch. *Affective engagement to emotional facial expressions of embodied social agents in a decision-making game*. http://onlinelibrary.wiley.com.proxy.lib.chalmers.se/doi/10.1002/cav.1458/epdf, 1 may 2012. Accessed: 2018-07-12.

[31] Clifford Nass Byron Reeves. *The Media Equation*, 1996.

[32] Thomas Hainey James M. Boyle Elizabeth A. Boyle, Thomas M. Connolly. *Engagement in digital entertainment games: A systematic review*, May 2012.

[33] Christopher J. Ferguson Mark Coulson, Jane Barnett and Rebecca L. Gould. *Real Feelings for Virtual People: Emotional Attachments and Interpersonal Attraction in Video Games*, 1 jul. 2012.

[34] Jane Vincent. *Emotional attachment and mobile phones*, Mar. 2006.

[35] Rani Molla. *Smartphone usage statistics*. https://www.recode.net/2017/6/26/15821652/iphone-apple-10-year-anniversary-launch-mobile-stats-smart-phone-steve-
26 jun. 2017. Accessed: 2018-07-12.

[36] Statista. *Smart phone users graph*. https://www.statista.com/statistics/201182/forecast-of-smartphone-users-in-the-us/, 2018. Accessed: 2018-07-12.

[37] Cynthia Breazeal. *Toward sociable robots*. https://www-sciencedirect-com.proxy.lib.chalmers.se/science/article/pii/S0921889002003731, Mar.

2003. Accessed: 2018-07-12.

[38] Sofia Serholt. *Child–Robot Interaction in Education*. https://gupea.ub.gu.se/bitstream/2077/52564/2/gupea_2077_52564_2.pdf, 2017. Accessed: 2018-07-12.

[39] Sara Kiesler Tina Kiesler. *My Pet Rock and Me: An Experimental Exploration of the Self Extension Concept*. https://figshare.com/articles/My_Pet_Rock_and_Me_An_Experimental_Exploration_of_the_Self_Extension_Concept/6470282, 2004. Accessed: 2018-07-12.

[40] Jen Wrye. *BEYOND PETS: EXPLORING RELATIONAL PERSPECTIVES OF PETNESS1: p. 1049-*, 2009.

[41] Batya Friedman Deanne R. Pérez-Granados Peter H. Kahn, Jr. and Nathan G. Freier. *Robotic pets in the lives of preschool children*, 2004.

[42] David W. Kritt. *Loving a virtual pet: Steps Toward the Technological Erosion of Emotion*. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1537-4726.2000.2304_81.x, 2000. Accessed: 2018-07-12.

[43] Masahiro Mori. *The Uncanny Valley [From the Field]*, 2012.

[44] Paul Bremner Miriam Koschate, Richard Potter and Mark Levine. *Overcoming the Uncanny Valley: Displays of Emotions Reduce the Uncanniness of Humanlike Robots*, 2016.

[45] S. Jäger K. Wolf N. Henze V. Schwind, K. Leicht. *Is there an uncanny valley of virtual animals? A quantitative and qualitative investigation*, 2018.

[46] Anthony Marsella. *The Five-Factor Model of Personality Across Cultures*, 2002.

[47] Wolmet Barendregt Sofia Serholt. *Robots Tutoring Children: Longitudinal Evaluation of Social Engagement in Child-Robot Interaction*. https://research.chalmers.se/publication/501257/file/501257_Fulltext.pdf, 2016. Accessed: 2018-07-12.

[48] Staffan Björk Petri Lankoski. *Game Research Methods*, 2015.

[49] Nicholas W. Jankowski Martine van Selm. *Conducting Online Surveys*, 2006.

[50] Oxford University Press. *Brainstorming Definition - A Dictionary of Marketing (4 ed.)*, 2016.

[51] Brian Cole Miller. *Quick Brainstorming Activities for Busy Managers: 50 Exercises to Spark Your Team's Creativity and Get Results Fast*, 2012.

[52] Klaus David. *Technologies for the Wireless Future: Wireless World Research Forum (WWRF) Volume 3: p. 31.* https://books.google.se/books?id=Blu46QiOobkC&pg=PA31&dq=participatory+design+in+brainstorming&hl=sv&sa=X&ved=0ahUKEwiPu-jQy5jZAhWBjiwKHSMmASkQ6AEIPTAD#v=onepage&q=participatory%20design%20in%20brainstorming&f=false, 2008. Accessed: 2018-07-12.

[53] Eva Brandt. *Designing Exploratory Design Games: A Framework for Participation in Participatory Design?*, 2006.

[54] Ontario. *Benefit and cost matrix.* http://www.hqontario.ca/Portals/0/documents/qi/qi-cost-benefit-presentation-instruction-sheet-en.pdf, 2018. Accessed: 2018-07-12.

[55] Jack Harvey Ian Michael Ratner. *Vertical Slicing: Smaller is Better.* http://resolver.ebscohost.com/openurl?sid=EBSCO%3aedb&genre=book&issn=&ISBN=9781612844268&volume=&issue=&date=&spage=240&pages=240-245&title=AGILE+Conference%2c+2011&atitle=Vertical+Slicing%3a+Smaller+is+Better.&aulast=Ratner%2c+I.M.&id=DOI%3a10.1109%2fAGILE.2011.46&site=ftf-live, 2011. Accessed: 2018-07-12.

[56] Svante Ahlsén Per Petersson. *Lean : gör avvikelser till framgång*, 2015. Accessed: 2018-08-07.

[57] Gundars Osvalds David Lempia Phyllis Marbach, Larri Rosser. *Principles for Agile Development.* http://onlinelibrary.wiley.com.proxy.lib.chalmers.se/doi/10.1002/inst.12043/epdf, 2015. Accessed: 2018-07-12.

[58] NASA. *NASA TLX: Task Load Index.* https://humansystems.arc.nasa.gov/groups/TLX/, 2018. Accessed: 2018-08-01.

[59] IBM developer works. *IBM: Fly on the Wall.* https://www.ibm.com/developerworks/library/us-fly/index.html, 2018. Accessed: 2018-07-12.

[60] techtarget.com. *Rapid prototyping definition.* https://searcherp.techtarget.com/definition/rapid-prototyping, Jan 2014. Accessed: 2018-08-01.

[61] James Grenning. *Planning Poker or How to avoid analysis paralysis while release planning.* http://sewiki.iai.uni-bonn.de/_media/teaching/labs/xp/2005a/doc.planningpoker-v1.pdf, 2002. Accessed: 2018-07-12.

[62] Trello.com. *Trello Homepage.* https://trello.com/, 2018. Accessed: 2018-07-12.

[63] Sherry Turkle. *Why these friendly robots can't be good friends to our kids.* https://www.washingtonpost.com/outlook/why-these-friendly-robots-cant-be-good-friends-to-our-kids/2017/

12/07/bce1eaea-d54f-11e7-b62d-d9345ced896d_story.html?noredirect=on&utm_term=.1d140beda7e4, 2017. Accessed: 2018-07-12.

[64] Miguel Sicart. *Reality has always been augmented: Play and the promises of Pokémon GO.* http://journals.sagepub.com.proxy.lib.chalmers.se/doi/pdf/10.1177/2050157916677863, 2017. Accessed: 2018-07-12.

[65] Unity Technologies. *Unity Asset Store.* https://assetstore.unity.com/, 2018. Accessed: 2018-07-12.

[66] Microsoft. *Hololens Homepage.* https://www.microsoft.com/en-us/hololens, 2018. Accessed: 2018-07-12.

[67] Sherri L. Smith. *AR-glasses soon or now available.* https://www.tomsguide.com/us/best-ar-glasses,review-2804.html, January 19, 2018. Accessed: 2018-07-12.

[68] Samsung. *Samsung Galaxy s5.* http://www.samsung.com/uk/smartphones/galaxy-s5-g900f/SM-G900FZKABTU/, 2018. Accessed: 2018-07-12.

[69] Samsung. *Samsung Galaxy s8+.* http://www.samsung.com/global/galaxy/galaxy-s8/, 2018. Accessed: 2018-07-12.

[70] Tech Terms. *API Definition.* https://techterms.com/definition/api, 20 jun 2016. Accessed: 2018-08-07.

[71] Gamedesigning.org. *Unity and Unreal Engine Comparison.* https://www.gamedesigning.org/career/video-game-engines/, January 25, 2018. Accessed: 2018-07-12.

[72] Unity Technologies. *Unity 2017 Homepage.* https://unity3d.com/, 2018. Accessed: 2018-07-12.

[73] Epic games. *Unreal Engine.* https://www.unrealengine.com/en-US/what-is-unreal-engine-4, 2018. Accessed: 2018-07-12.

[74] Unity Technologies. *Vuforia for Unity.* https://unity3d.com/partners/vuforia, 2018. Accessed: 2018-07-12.

[75] Mapbox. *Mapbox for Unity.* https://www.mapbox.com/unity/, 2017. Accessed: 2018-07-12.

[76] Tech Terms. *QR-code Definition.* https://techterms.com/definition/qr_code, 5 mar 2015. Accessed: 2018-08-07.

[77] Catchoom. *CraftAR.* https://catchoom.com/documentation/

augmented-reality-sdk/unity-augmented-reality-sdk-android-ios/, 2017. Accessed: 2018-07-12.

[78] Google Developers. *ARCore API*. https://developers.google.com/ar/reference/, December 15, 2017. Accessed: 2018-07-12.

[79] Tangram. *Tangram Unity*. https://github.com/tangrams/tangram-unity, December 14, 2017. Accessed: 2018-07-12.

[80] Google Developers. *Google Static Map API*. https://developers.google.com/maps/documentation/static-maps/, 2017. Accessed: 2018-07-12.

[81] Frostweep Games. *Google Cloud Speech Recognition*. https://assetstore.unity.com/packages/tools/integration/google-cloud-speech-recognition-vr-ar-mobile-desktop-72625, October 24, 2017. Accessed: 2018-07-12.

[82] Yusuf Olokoba. *Pedometer API*. https://github.com/olokobayusuf/Pedometer-API, July 14, 2017. Accessed: 2018-07-12.

[83] HIPPO. *Simple Android Notifications Free*. https://assetstore.unity.com/packages/tools/integration/simple-android-notifications-free-68626, February 2, 2018. Accessed: 2018-07-12.

[84] Autodesk Inc. *Maya Homepage*. https://www.autodesk.se/products/maya/overview, 2018. Accessed: 2018-07-12.

[85] Autodesk Inc. *3DStudioMax Homepage*. https://www.autodesk.se/products/3ds-max/overview, 2018. Accessed: 2018-07-12.

[86] Blender Foundation. *Blender Homepage*. https://www.blender.org/, 2018. Accessed: 2018-07-12.

[87] Michael Kremmel. *MK Toon Free*. https://assetstore.unity.com/packages/vfx/shaders/mk-toon-free-68972, February 5, 2018. Accessed: 2018-07-12.

[88] Adobe Systems Software. *Adobe Photoshop Homepage*. https://www.adobe.com/se/products/photoshop.html?sdid=JRSIX&mv=search&s_kwcid=AL!3085!3!80938637603!e!!g!!photoshop&ef_id=VrdgaAAAANlF7FWx:20180201091436:s, 2018. Accessed: 2018-07-12.

[89] Microsoft. *Microsoft Paint Download-page*. https://support.microsoft.com/sv-se/help/4027344/windows-10-get-microsoft-paint, 2018. Accessed: 2018-07-12.

[90] The GIMP Team. *GIMP Homepage*. https://www.gimp.org/, 2018. Accessed:

2018-07-12.

[91] Adobe Systems Software. *Adobe Illustrator Homepage*. https://www.adobe.com/se/products/illustrator.html?sdid=JRSIX&mv=search&s_kwcid=AL!3085!3!80945075363!e!!g!!illustrator&ef_id=VrdgaAAAANlF7FWx:20180201091655:s, 2018. Accessed: 2018-07-12.

[92] Christian Petry. *Normal-map online Homepage*. http://cpetry.github.io/NormalMap-Online/, 2014. Accessed: 2018-07-12.

[93] allegorithmic. *Substance Designer Homepage*. https://www.allegorithmic.com/products/substance-designer, 2017. Accessed: 2018-07-12.

[94] AUDACITY. *Audacity Homepage*. https://www.audacityteam.org/, December 6, 2017. Accessed: 2018-07-12.

[95] Image Line Software. *FL Studio Homepage*. https://www.image-line.com/flstudio/, 2018. Accessed: 2018-07-12.

[96] Reddit. *Pokémon GO Subreddit*. https://www.reddit.com/r/pokemongo/, 2017. Accessed: 2018-08-01.

[97] Reddit. *Ingress Subreddit*. https://www.reddit.com/r/Ingress/, 2017. Accessed: 2018-08-01.

[98] Brian Cole Miller. *Quick Brainstorming Activities for Busy Managers: 50 Exercises to Spark Your Team's Creativity and Get Results Fast, Chapter 4 - Brainstorming Techniques*. http://library.books24x7.com.proxy.lib.chalmers.se/assetviewer.aspx?bookid=45320&chunkid=918915630&rowid=90, 2012.

[99] Brian Cole Miller. *Quick Brainstorming Activities for Busy Managers: 50 Exercises to Spark Your Team's Creativity and Get Results Fast, Chapter 6 - Grouping Methods*. http://library.books24x7.com.proxy.lib.chalmers.se/assetviewer.aspx?bookid=45320&chunkid=813572719&rowid=220, 2012.

[100] Electronic Arts. *Spore homepage*. http://www.spore.com/, 2009. Accessed: 2018-08-01.

[101] Supercell. *Clash of Clans homepage*. http://supercell.com/en/games/clashofclans/, Aug 2012. Accessed: 2018-08-01.

[102] Travian games GmbH. *Travian homepage*. https://onlinegame.travian.se/, Sep 2004. Accessed: 2018-08-01.

[103] Zynga. *Farmville homepage*. https://www.zynga.com/games/farmville, Jun 2009. Accessed: 2018-08-01.

[104] Git SCM. *Git SCM homepage*. https://git-scm.com/, 2018. Accessed: 2018-08-07.

[105] Google. *Google Play Store*. https://play.google.com/store, 2018. Accessed: 2018-08-07.

[106] Google. *Google Play Console*. https://developer.android.com/distribute/console/, 2018. Accessed: 2018-08-07.

[107] Inc. Encyclopaedia Britannica. *SQL*. https://www.britannica.com/technology/SQL, 2018. Accessed: 2018-08-07.

[108] The PHP group. *PHP homepage*. http://www.php.net/, 2018. Accessed: 2018-08-07.

[109] Sandbox Interactive GmbH. *Albion online homepage*. https://albiononline.com/en/home, Jul 2017. Accessed: 2018-08-01.

[110] Anticimex. *Anticimex homepage*. https://www.anticimex.com/sv-SE/, 2018. Accessed: 2018-08-01.

[111] Blizzard Entertainment. *World of Warcraft homepage*. https://worldofwarcraft.com/en-gb/, Nov 2004. Accessed: 2018-08-01.

[112] Bethesda. *The elder scrolls V: Skyrim homepage*. https://elderscrolls.bethesda.net/en/skyrim, Nov 2011. Accessed: 2018-08-01.

[113] Kevin Björklund & Simon Eliasson. *Augotchi presentation video*. https://www.youtube.com/watch?v=apK3UDLkJlc, 2019. Accessed: 2019-08-10.

[114] Kevin Björklund & Simon Eliasson. *Augotchi github page*. https://github.com/DigohD/Augotchi, 2018. Accessed: 2018-08-01.

[115] Codecademy. *Codecademy's page on Model view control*. https://www.codecademy.com/articles/mvc, 2018. Accessed: 2018-08-01.

[116] Frontier Developments. *Planet Coaster homepage*. https://www.planetcoaster.com/en-gb, Nov 2016. Accessed: 2018-08-01.

[117] Julia G. Raz Amanda Cote. *Game Research Methods, chapter 7: In-depth interviews for games research*. https://dl.acm.org/citation.cfm?id=2812784, 2015. Accessed: 2018-07-12.

Appendices

A Formal Game Analysis Design Patterns

A.1 Design Patterns of Ingress

In this section, a vocabulary of common Ingress terms is presented, and the game's identified patterns are then described one by one.

Ingress Vocabulary

- **Agent** - Ingress players are called agents, hence, an agent is a game object representing a player within the game.
- **Faction** - Ingress features two teams, or factions, that war with each other, one of which each player belongs to.
- **Portals** - Portals are pre-positioned objects on the GPS map which the players interact with in order to play the game. They are the core game objects of Ingress, which the whole game revolves around. Factions may capture portals, and destroy enemy portals, in order to use the portals to establish links and fields.
- **Links & Fields** - Links are a player-created connection between two portals. When three portals have been connected in a triangle, a triangular field, belonging to the player's faction, is created, which generates mind units for that faction.
- **Mind Units** - The score system of Ingress is based on what is called mind units. One of the main goals in Ingress is for agents to cover the map in fields that are controlled by their respective factions. When creating such a field, the field's size and the population density of the area is used in order to calculate how many mind units the field generates for the team.
- **Resonators** - Resonators may be considered the basic building block of Ingress. In simplified terms, you participate in the faction war by destroying the enemy team's resonators while constructing and defending your own. Resonators are connected to portals, and a portal's owner is determined by its connected resonators.

Inevitable Agent Progress
In Ingress progress is inevitable in many ways. Whenever the player takes any action, it will have a positive effect on the statistics related to the player's agent profile.

Never-ending Gameplay

The goal of Ingress is continuous, which means that the game does not have a set end. There are two factions in Ingress and the only game-given goal is for the player to help out his/her faction as much as possible. The faction which controls the most mind units are considered to be in the lead at the moment. There are also individual leader boards for which agents control the most mind units.

Grinding
Ingress is heavily reliant on repetitive processes that are guaranteed to lead to some kind of benefit. One example is gathering items in order to destroy enemy resonators and build your own. In general, if you spend a lot of time on the game, you will have a bigger impact on the game state, since your offensive and defensive capabilities increase with how many items you gather and use.

Reward Planning & Collaboration
Big fields that generate a lot of mind units are hard to construct, since links cannot cross each other. If you want to create a link that spans several kilometers, perhaps even hundreds, all already established links that might exist between the two to-be-connected portals need to be destroyed. Hence, collaborating with allies is often required in order to create big fields, since clearing out these obtrusive links might take a lot of time and effort, and since new possibly obtrusive links are created all the time.

From Zero to Hero
In Ingress new players are relatively weak until they reach a certain player level. A level eight agent is several times more powerful than a level one agent, since they have access to more powerful items. This means that it is harder for a new player to have a big impact on the game state.

Exponentially Steep Progress
This is related to the fact that there is, in practice, no end to player progress. To reach level 16 in Ingress is a massive undertaking, in comparison to reaching, for example, level 8. The effort required in order to reach the next level increases for each level in an exponential fashion.

GPS Based Location
When wanting to move somewhere within the game world, you actually need to physically go there in person. There are a number of implications due to this:

- **Limited Play Area** - You get a special connection with the area around your home or work, as these are the areas you generally move around in anyway. It also gives rise to local communities of players.

- **Encourages Physical Activity** - Walking is necessary in Ingress, which even features a walking achievement, which is needed for higher levels in the game.

- **Encountering Other Players** - Gives opportunity for actual face-to-face social interaction, both with members of your local community and with random players you encounter in the field.

One Small Cog
However much time you choose to put into the game, and no matter how effective you are, you still cannot succeed on your own. In Ingress, you are inevitably a small part of something bigger, namely your faction, taking part in a war that spans the entire globe.

Limited Inventory Space
In Ingress, you need to constantly manage your item inventory since you cannot carry infinite amounts of items. This can either be done by using the items, throwing or giving them away, or by destroying them.

Item Tiers
Most of the items in Ingress come in different tiers, or power levels. Items of higher power levels are harder to get, either because it requires more effort from the player or because of simple random generation. Furthermore, high tier items are not available to low level players. An example of tiered items are resonators, which come in eight different tiers.

Random Loot
Different items have different drop rates when gathering them from portals. Some are very common, and some are extremely rare. The rarity is not always directly connected to the power level of the item, but in general, this is the case. For example, you cannot get tier 3 resonators at all from a tier 8 portal. In such a case, tier 8 resonators have a higher drop chance than tier 3 resonators, even though tier 8 resonators are more powerful.

Active World Manipulation
Ingress is heavily built around the player's ability to change the world in which the game takes place. The main component of Ingress is the portal, and the player's actions almost exclusively affect portals in different ways. All the changes that occur due to player actions are global, which means that the game world of other players are directly affected by any player's actions.

Pervasive Story
The faction war in Ingress impacts a parallel story-line. The developers have created a narrative, including fictional characters, which explains why the players do the things that they do in the game. During certain events, the story is progressed further, depending on faction performance, and the story is told as if it is actually real. In Ingress, the player is portrayed as an actual agent, and the Ingress application is described as a tool which allows the agent to take part in the faction war.

Trading
An important feature of Ingress is the ability for players to share their wealth (items) amongst each other.

Resource Depletion
Portals may only generate items in limited quantities based on hard-set rules. Whenever items are gained from a portal, it cannot be used in order to gain items for a few minutes. This cooldown period is further prolonged to 4 hours when items are gained from the same portal several times in a short period of time. This encourages the player to constantly move around.

A.2 Design Patterns of Pokémon GO

In this section, a vocabulary of common Pokémon GO terms is presented, and the game's identified patterns are then described one by one.

Pokémon GO Vocabulary

- **Trainer** - In Pokémon GO, the player takes on the role of a Pokémon trainer. The trainer therefore refers to the game object representing the player within the game.
- **Pokémon** - A Pokémon is a fictional creature with different kinds of magical powers. The main plot point in the Pokémon franchise in general is for the Pokémon trainer to catch these magical creatures and use them in order to battle other trainers' creatures.
- **Candy** - Candy is a type of currency/item that can be used in order to empower the player's Pokémon.
- **Pokestop** - Pokestops are locations on the map where the trainers gather items.
- **Gym** - A special, less common kind of pokestop where the players fight each other in gym battles, as well as take down raid bosses in raid battles.
- **Raid Boss** - Gyms may spawn random bosses: potentially overpowered Pokémon that often requires a number of collaborating trainers to take down.

Constant Trainer Progress
In Pokémon GO. progress is inevitable in many ways. Whenever the player takes any action, it will in some way have a positive effect on the statistics related to the player's trainer profile.

Never-Ending Gameplay
There is no game-set goal in Pokémon GO. Some of the macro-goals are entirely player pursued. Even if, for example, gaining stronger Pokémon is objectively beneficial, the game itself does not state it to be a win condition in any way.

Collecting
The game revolves, to a high degree, around collecting things. Be it the strongest Pokémon, hard-to-find Pokémon or achievements.

Grinding
The game is heavily reliant on repetitive processes that are guaranteed to lead to some kind of progress, examples being gathering items and improving owned Pokémon. In short, if you spend a lot of time you will have a stronger team of Pokémon, and may hence have a bigger impact on the game state.

Rewards Planning & Collaboration
A single player cannot take down difficult raid battles on his/her own. In such cases, the player needs to collaborate with others.

From Zero to Hero
In terms of combat with other players and raid bosses, new players are relatively weak until their Pokémon reach a certain power level. As player levels are gained, you get access to more powerful items, may find more powerful wild Pokémon to catch and may improve your owned Pokémon even further.

Exponentially Steep Progress
This is related to the fact that there is, in practice, no end to player progress. In the beginning of the game, your power-level rises fast as player levels are easy to gain. Later levels (after level 30) take considerably more time and effort to achieve, but the gains from each level stay marginal.

GPS Based Location
When wanting to move somewhere within the game you actually need to physically go there in person. This has a number of implications:

- **Limited Play Area** - You get a special connection with the area around your home. This gives rise to local communities of players.
- **Encourages Physical Activity** - In Pokémon GO, there are game mechanics that entirely revolves around walking. For example, Pokémon eggs can be hatched by walking a certain distance.
- **Encountering Other Players** - This occurs specifically when collaborating with other trainers in raid battles.

Limited Inventory Space
The player needs to constantly manage his/her inventory, since it cannot contain an infinite amount of items or Pokémon. This can either be done by using items or throwing them away, or by trading in the Pokémon in order to receive candy.

Player Chooses the Goal
Since there is no game-set end goal, what goal to pursue is entirely chosen by the player. There is no official leaderboards in any shape, way or form. This makes Pokémon GO more of a sandbox type of game, where the world and its features is offered and the player determines how to explore it.

Optional Multiplayer
The game is essentially playable and enjoyable without engaging with other players. Most actions in the game do not require other players to be involved at all.

Item Tiers
Some of the items in the game come in different tiers, or power levels. Items of higher power levels are harder to get, because of simple random generation. What items are attained also depend on the trainer's level.

Random Loot
Different items have different drop rates when gathering them. Some are very common, but more powerful items are rare. There are special cases regarding some items, one kind of items being "evolve-items", which are primarily gained by spinning a pokestop every day for seven days straight. Furthermore, some items may only be gained by defeating bosses in raid battles.

Daily/Weekly Rewards
When capturing a Pokémon and/or spinning a pokestop daily/weekly, the player receives significant bonus rewards.

Further Augmentation
Pokémon GO uses the real life weather as a game mechanic in the game. This manifests itself visually in the game with graphical effects, but also impacts the gameplay in minor ways. In other words, different weather means that the players have different odds of achieving their goals.

Resource Depletion
Pokestops have a limitation to how many items they may generate. Whenever a player uses a pokestop in order to get items, the action cannot be performed again at the same pokestop for 5 minutes.

A.3 Shared Principles of Design

In this section, the principles of design that occur in both games will be listed. These patterns are considered to be implemented in a near identical fashion in both games.

Constant Character Progress
Both games feature this principle, and it is very similarly done in both games. Basically, every action you take as the player contributes to your progress in the game, primarily by gaining experience which is required to gain higher player levels.

Never Ending Gameplay
Neither Ingress nor Pokémon GO have a game-given win state (Ingress features a leading state, however, where one faction is described as ahead).

Grinding
Both games revolve heavily around simple repetitive activities, with some exceptions, such as raid battles in Pokémon GO, which has a daily limit of one per day, or collaborative operations in Ingress which are emergent activities facilitated by the players, and not by the game itself.

Rewards Collaboration
Both games have systems in place to foster collaboration. However, it is different between the games. In Pokémon GO, it is determined by the game when and where to collaborate in gym battles, and the rewards you get are deterministic, such as certain specific items gained. Ingress, however, relies on player collaboration to a much higher extent. The game itself does not tell the player where or when to cooperate, this is left to the communities to decide. Also, in Ingress the collaborative efforts might be shut down by the opposing faction, which means that there is no guarantee for success in such efforts at all. One final note is that Ingress is inherently cooperative, since everything the player does aids the faction, whether the player communicates with his teammates or not. In Ingress, you are forced to be a part of the team, while in Pokémon GO, you can effectively play it solo and still reach most of the macro-goals.

From Zero to Hero
Since Ingress revolves around player versus player interaction, it is very hard to fight experienced high level players as a new player. In Ingress, you share the same playing field as all other players in the game, hence the game is hard in the beginning, but becomes easier as you progress. In Pokémon GO this can be avoided since player versus player activities are not mandatory. However, in both games you get increasingly more powerful as you play the game, which is important in player versus player situations in both games.

Exponentially Steep Progress

This is similar in both games. Both games are easy to level up in early, and higher levels become exponentially harder to reach. This is even more apparent in Ingress, where you also need to gather achievements in order to reach the highest levels.

GPS Location
This is the greatest common denominator between the games since it defines how and where the games are played. There are no real differences here. The player has a certain reach within the game world from his/her GPS position, and the destinations in both games, such as the portals and the pokestops and gyms, are similar in nature.

Encourages Physical Activity
Both games have motivators to make the players move around more. This is more common in Pokémon GO since there are entire game mechanics that revolve around the concept, compared to Ingress where it only contributes to one specific achievement. In general though, both games require the player to move around to play the game.

Limited Inventory
Both games feature limited inventory space and a variety of items to fit in that space, so the players have to actively filter out what items (or Pokémon) to keep, by discarding less desirable items.

Item Tiers
In both games some of the items come in different power levels. The power level is most often also connected to how hard the item is to get and what level the player is. This means that the players need to make decisions when to use or save powerful items.

Random Loot
More powerful items are harder to come by since they drop less frequently when gathering. There are some minor differences between the games, but the main principle stays the same.

Resource Depletion
In both games, it is more effective to gather items from different places, rather than constantly gaining items from the same portal or pokestop.

A.4 Unique Principles of Design

Unique principles of design are design patterns that do not overlap in the two games, or where a design pattern manifests itself in radically different ways.

Collecting

In Pokémon GO, a large aspect of the game is the collecting of Pokémon. Ingress lacks this collecting aspect, since items in Ingress are meant to be consumed in the faction war. Achievements in Ingress is a form of collection as well, but not in the same way as Pokémon GO's Pokémon collecting (Pokémon GO has achievements as well). Essentially, in Pokémon GO, your most valuable assets, namely your Pokémon, are not meant to be consumed.

Player Chooses the Goals
In Ingress, the goal of the game is established by the game, namely to help your faction control more mind units than the opposing faction. Pokémon GO lacks any sort of game given goals, hence it is up to the players to come up with, as well as set, their own goals, such as catching one of each Pokémon species.

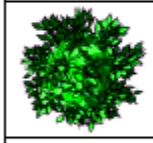
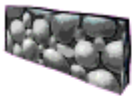
Optional Multiplayer
Multiplayer is more important in Ingress than in Pokémon GO. You can play Pokémon GO without any player communication at all. This difference is further illustrated by the fact that Pokémon GO does not feature an in-game team-chat system. In Ingress, faction-chats, and even cross-faction-chat, are prevalent features.

Daily/Weekly Rewards
Pokémon GO rewards you for playing regularly, which is not a feature in Ingress.

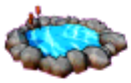
Further Augmentation
The weather effects in Pokémon GO adds an extra layer of augmentation that Ingress lacks. In Ingress, the game mechanics work identically regardless of weather, or any other real world variable.

B Augotchi Content Tables

Decor

Image	Name	Place cost	Buy price	Rarity
	Oak Tree	1000	2000	Rare
	Spruce Tree	1000	2000	Rare
	Bush	250	500	Common
	Mushroom	500	-	Rare
	Fence	250	500	Common
	Stone path	250	500	Common
	Dry stone	250	500	Common
	Fountain	25000	-	Amazing
	Bench	750	1500	Rare
	Flagpole	12500	-	Rare
	Table	1000	2000	Rare
	Statue	25000	-	Amazing

Decor cont.

Image	Name	Place cost	Buy price	Rarity
	Pond	25000	-	Amazing
	Urn	500	-	Rare
	Gold pile	2000	-	Rare
	Archway	5000	-	Epic
	Torch	1000	-	Rare
	Lamp post	5000	-	Epic
	Flat stone	1000	2000	Rare
	Large stone	1000	2000	Rare
	Medium stone	500	1000	Common
	Small stone	250	500	Common
	Tall stone	2500	5000	Epic
	Stone pile	2500	5000	Epic

Decor cont.

Image	Name	Place cost	Buy price	Rarity
	Flower Patch	250	500	Common
	Flower Pot	250	500	Common
	Sunflowers	500	1000	Rare
	Prized Roses	2500	5000	Epic
	Flower bucket	250	500	Common

Seeds

Image	Name	Buy price	Sell price	Growth time (Hr)	Rarity
	Carrot seed	20	4	1	Common
	Meatball seed	25	5	2.5	Common
	Gooseberry seed	15	3	2	Common
	Cabbage seed	125	25	5	Rare
	Sausage seed	150	30	5.5	Rare
	Sugarcube seed	125	25	4.5	Rare
	Potato seed	375	75	8	Epic
	Spinach seed	375	75	10	Epic
	Chili seed	375	75	12	Epic
	Onion seed	500	100	18	Amazing
	Pizza seed	750	150	24	Amazing
	Nugget seed	1250	250	48	Amazing

Farm Produce

Image	Name	Buy price	Sell price	Rarity	Hu	He	Ha	Str	Int	Agi
	Carrot	30	10	Common	1.5	3.5	0	0	0	0
	Meatball	45	15	Common	5	0	0	0	0	0
	Gooseberry	24	8	Common	0	1.5	3.5	0	0	0
	Cabbage	48	16	Rare	5	10	0	0	0	0
	Sausage	60	20	Rare	15	0	0	0	0	0
	Sugarcube	42	14	Rare	5	0	10	0	0	0
	Potato	66	22	Epic	10	5	0	0	15	0
	Spinach	66	22	Epic	5	10	0	15	0	0
	Chili	66	22	Epic	5	0	10	0	0	15
	Onion	90	30	Amazing	15	15	15	5	5	5
	Pizza	120	40	Amazing	10	0	0	20	20	20
	Nugget	750	250	Amazing	Unedible					

World Produce

Image	Name	Found in	Buy price	Sell price	Rarity	Hu	He	Ha	Str	Int	Agi
	Mushroom	Forest	54	18	Rare	5	0	0	0	0	10
	Blueberry	Forest	54	18	Rare	5	0	0	0	10	0
	Egg	Forest	54	18	Rare	5	0	0	10	0	0
	Truffle	Forest	1200	400	Amazing	Unedible					
	Salmon	Pond	75	25	Epic	5	0	0	0	10	10
	Perch	Pond	75	25	Epic	5	0	0	10	10	0
	Pike	Pond	75	25	Epic	5	0	0	10	0	10
	Shrimp	Pond	75	25	Epic	5	0	0	5	5	5

The Hu, Ha and He columns stand for hunger, happiness and health, and is the core statuses for keeping the pet from passing out. The str, int and agi columns represent how much it increases the stats of the pet, namely strength, intelligence and agility, which determine how good the pet is at exploring dungeons.