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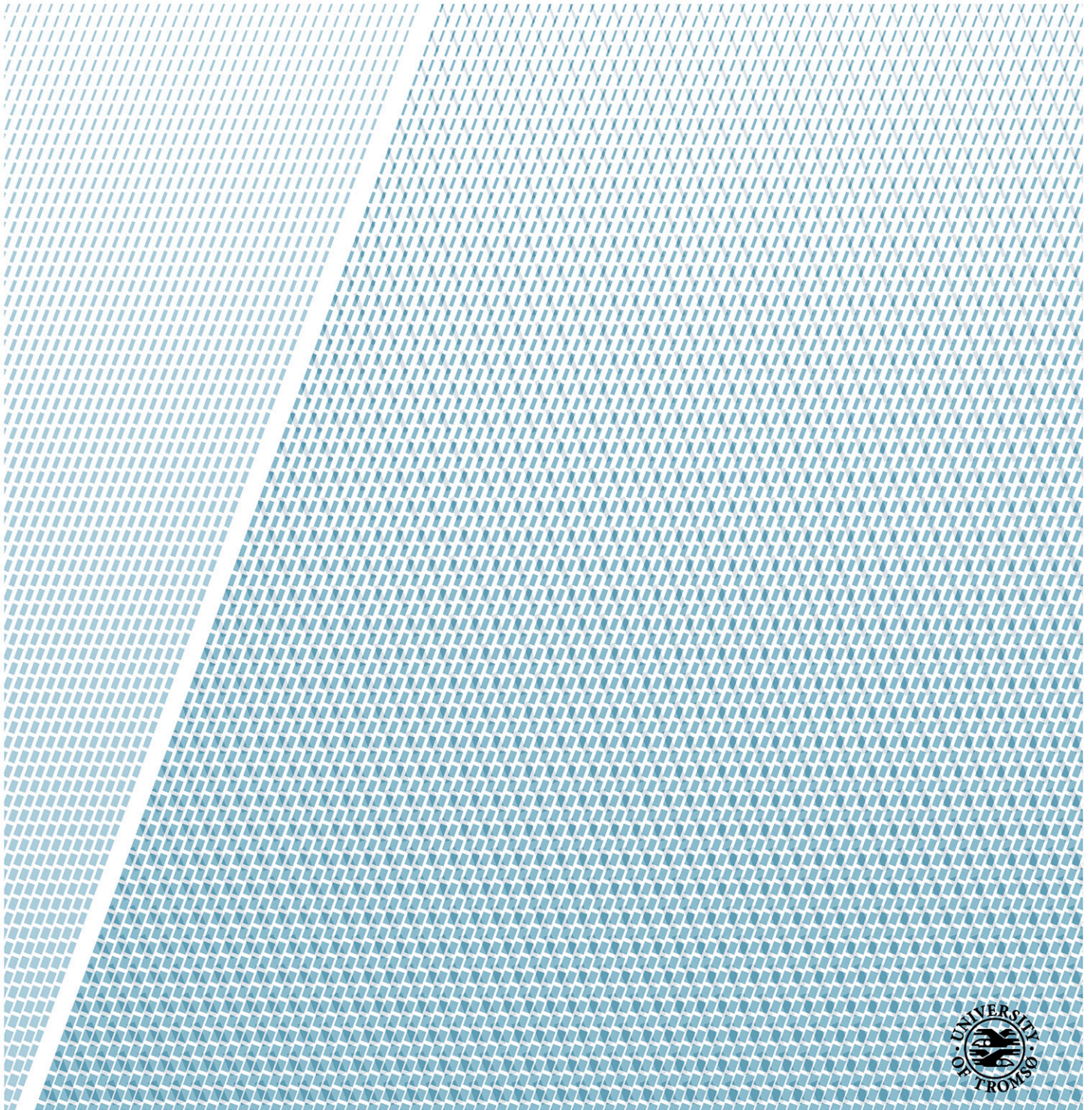
Department of Computer Science

Exploring In-Game Rewards in the Diaquarium

A Serious Game for Children with Type 1 Diabetes Mellitus

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INF-3981 Master's thesis in Computer Science, December 2016

Abstract

Digital games do not only serve entertainment purposes, but can also benefit as useful tools for learning. Games that have an explicit and carefully thought-out educational intention has appeared as very productive within health care, and have been used more frequently as part of treatment among children with Type 1 Diabetes Mellitus. Insulin-depended diabetes has no known cure at the present time, hence, individuals living with the disease are fully depended on their self-treatment competence to stay healthy throughout a lifetime. For the last couple of decades, serious games have been used to enhance knowledge and awareness regarding Diabetes Mellitus among children living with the disease, as serious games are known to be both educational and entertaining. Some of these games are the Diabetic Dog Game, Carb Counting with Lenny, and Ketones Attack. When developing serious games, the main goal is to utilize game mechanisms so that users decides to lengthen their playtime, complete levels within the game, and thereby gain progression and intended learning with regard to disease management. One major concern when developing games for health is, therefore, the possibility of users who withdraws from the game before completed. A game, with a descending popularity and users quitting gameplay early, fails to provide medical education to patients and is, in that perception, useless. For that reason, it was found significant to consider motivational game elements, such as in-game rewards, when designing serious games.

This thesis identifies several reinforcement mechanisms within digital games and explores how they can be applied in an invented serious game, called the Diaquarium. An overview of 36 types and categories of in-game rewards and 6 reward schedules have been addressed. The constructed game has been designed through research-based methods and provides knowledge regarding how nourishment, blood glucose levels, and insulin interacts for individuals with Type 1 Diabetes Mellitus. An early prototype has been developed to demonstrate its concept and some of the game mechanisms with help of Unity 3D game engine and

C# programming language. Game design, requirements and suggestions for the project was gathered through literature review, attending workshops, meetings and discussions with experts, as well as feedback from a potential user group. On the final stage of research, an anonymous questionnaire for children was distributed to an elementary school class, involving nine 9-year-old children. The questionnaire examined and collected feedback regarding the game outline, usability, and preferred reward mechanisms in the Diaquarium. Despite a short period of testing and a limited test group with non-diabetic children, the game was recognized as attractive and moderately difficult within the potential user group. Accordingly, n = 8 answered that they liked the game and were highly interested in playing it one day. Also, n = 8 answered positively with respect to illustrations and colors used in the game. The analysis suggests that rewards are highly a matter of preference. Simultaneously, there were indications that some of the rewards were more favorable than others and vice versa. It appears that rewards serving a purpose within the game, e.g. potentially effect progression in the gameplay, is more favorable than the opposite rewards serving no purpose. The findings were highly valued and taken into consideration during the design process of exploring the in-game rewards of the Diaquarium.

To all children with diabetes

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Preface

When I was a child, my big dream was to become a teacher. At middle school, one of my teachers inspired me to make that dream come true. She shared her knowledge every day with enthusiasm, passion, and love. Pushing her students to become a little bit wiser every day by believing in each and every one. It's safe to say that she posed a difference in our life. I worked hard and devoted toward my goal to become a teacher. I was even participating in an event for future teachers and later that evening interviewed in the local newspaper, broadcasting my future plans. I guess it's no surprise to you that I started my degree in Master of Education after high school.

Four months into the study program, I got an internship at the same middle school as I went to as a child. Suddenly, I was educating children in the same classroom as the teacher who inspired me some years earlier. However, after a few weeks, my big dream started to unravel. Thoughts about being responsible for these children's future was laying on my shoulders at all time, and I was reconsidering my ability to provide adequate teaching. It burned me out, leaving me devastated, confused, and afraid. I had no backup plan. The only thing I was certain on at that time was the necessity of leaving my childhood dream behind.

In high school, I was participating in a technology camp for girls at the Norwegian University of Science and Technology in Trondheim. The days were filled with workshops, lectures, and social events, where computer science was one of the main topics. When I decided to change study program, my student supervisor at that time suggested computer science. Even though the field was unknown and far outside my comfort zone, those three days in Trondheim had triggered me. I had nothing to lose.

The first year of studying computer science revealed a whole new world with endless opportunities. I firmly believe that dreams choose people and not the other way around. My childhood dream was never to stand in a classroom and teach. It was sharing knowledge with enthusiasm, passion, and love. Composing a difference in someone's life, just like my middle school teacher had done to me. The

idea of Diaquarium came to me one night when I was drawing for fun, and I realized it could be one of my chances to conduct the dream that had me.

This thesis has truly been a roller-coaster ride, demanding blood, sweat, and tears. A lot of hours has been conducted at the Norwegian Centre for E-health Research, only to head home for food or sleep. When that is said, this semester has been the best semester throughout my education. My initial plan was to design and develop two versions of the game Diaquarium, with and without a range of rewards features, and then inspect playtime among potential users. However, due to time constraints, I had to discard the original idea. Instead, I have been able to make an early prototype of Diaquarium and get initial feedback regarding the planned design from potential users. Looking back, thinking that I would have enough time to develop a game with different reward techniques in two versions within one semester was too ambitious.

I have learned so much from working on this project, embracing the scientific research field and got a glimpse on how researchers work in real life. I am sincerely going to miss spending time at the Norwegian Centre for E-health Research.

First and foremost, I would like to express my sincere gratitude to my head-advisor, Professor Gunnar Hartvigsen, for allowing me to explore the idea of Diaquarium and provide exceptional support and guidance throughout the entire process. He allowed this paper to be my own work but steered me in the right direction whenever I needed it.

Appreciation is also extended to my co-advisor Professor Eirik Årsand for his valuable consultation, constructive feedbacks, and for sharing his professional knowledge and visions with me. Inviting me to the workshop in Lyngen meant a lot to me.

I would also like to thank student supervisor, Jan Fuglesteg, who has been extremely helpful when difficulties have emerged. My entire master degree wouldn't have been conducted without your help.

Also, I would like to thank the experts of the Diabetes Team at the Norwegian Center of E-health Research, as well as associate professor and

psychologist Gerit Phful, who were all involved in the background research of this project.

Furthermore, I will miss all my study buddies who included me in their social life and made the days at the University a lot of fun. Special thanks to Ruben Mæland, who believed in me, gave me proper pep-talks, and helped me through when life got complicated. You are sincerely a true friend.

To my father Hans, mother Elin, and sister Elise; thank you for always being there for me, cheering and repeatedly reminding me that everything is possible. I would not have come far without you.

Conclusively, I want to thank my boyfriend, Kristoffer, who have held out with me throughout this (extremely!) stressful period in my life. You stand behind me like a rock, supporting me, and make sure that all practical details are cared for so that I can chase my dreams. You are simply amazing.

Tromsø, 22. December 2016
Ida Charlotte Rønningen

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Definitions

For the purpose of this thesis the following definitions shall apply:

Game: an activity played according to rules in a specific game environment and whose achievement is a victory

Video Game: a type of game played on electronic devices, for example on a computer or a game console

Gameplay: how the game is played. The Gameplay is based on the game mechanisms and on the game design

Game Mechanisms: all the different rules and commands programmed in the game and creating the game experience

In-Game Rewards: reward that are found within the gameplay

Game Outline: The basic idea of the game

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Chapter 1

Introduction

1.1 Background and Motivation

Individuals diagnosed with Diabetes Mellitus are depending on their self-treatment skills for a lifetime to stay healthy. Type 1 Diabetes Mellitus is usually diagnosed in children and young adults (American Diabetes Association, 2016), creating an enormous obligation to increase disease knowledge and subsequent medical care for patients at an early stage of life. Research have shown empirical evidence on the impacts and outcomes of serious games concerning learning (Connolly *et al.*, 2012), leading healthcare companies and game developers together to collaborate and create appropriate applications. Due to children's practice with technology in general, the use of gamified disease management can help children with diabetes to cope better with their condition.

> *"Game-based-learning forces the user to take an active approach to learning with rapid feedback and clear consequences leading to higher engagement and improved learning"* (Serious Games Interactive, 2016)

Learning to manage Type 1 Diabetes Mellitus as a youngster can be a complicated adjustment, handling both medical and physiological changes in an already challenging stage of life caused by adolescence. Diabetes Mellitus is hard to regulate exclusively, but with stressful situations all children experiences, Diabetes Mellitus can create a whole new level of confusion and worry for the child when it comes to disease management (JDRF, 2013). Examples include academic and social pressures (especially from trying to fit in), extracurricular activities, illness, and travels. Children also have difficulties understanding the severity of health complications that can occur if the disease is not supervised correctly.

Serious games often depend on users to complete all levels to receive a full education, and one massive difficulty for developers to address is, therefore, the possibility of users quitting the game before finished off. Motivational game techniques and mechanisms are well known in the game industry, yet some serious games are left useless if dismissed too early and thereby failing to distribute knowledge because they were perceived as boring (Mitgutsch & Alvarado, 2013). Learning how to master motivation and engagement in serious games is, therefore, essential and valuable given increased health care knowledge through gameplay (Lewis, 2007). Reward mechanisms in games are known to have the potential to maximize motivation and achieve learning, but research on differences in reward techniques and how their various characteristics can be applied in games and thereby impact users in regard to their likelihood to play again seem rather limited.

1.2 Scope and Research Problem

In light of the diabetes self-care difficulties for children addressed above, serious games have the ability to boost patients' medical treatment program in a positive manner. However, some of these games do not consider quality motivational in-game mechanism (Mitgutsch & Alvarado, 2013), which opens opportunities for consumers to quit the game earlier then intended and miss important knowledge. Göbel *et al.* (2016) states that the reason why serious games are still missing market breakthrough is, among others, caused by poor quality of existing serious games. Children who are diagnosed with Type 1 Diabetes Mellitus, along with their families and friends, often start at a zero-knowledge base, and preventing them from retreat a game that is designed to increase self-treatment skills can be essential regarding their future health and possible consequences caused by incorrect care of Diabetes Mellitus.

The project is aimed to develop an educational game for children diagnosed with Type 1 Diabetes Mellitus, concerning suitable in-game reward techniques. The game is expected to provide some basic diabetes-related knowledge, but the

primary goal is to investigate and explore various reinforcement techniques that exists in games and experiment how they can be applied in the best manner to increase patients' motivation to play. The main research problem for this thesis can, therefore, be expressed as follows:

How can various reinforcement techniques be applied in serious games, regarding self-management education, to increase play-act motivation for children with Type 1 Diabetes Mellitus?

The main research problem is divided into sub problems to address the scope of this thesis. All sub-problems are based upon the particular user group for this project, and can be identified as follows:

A. Reward components of the application

Being aware of the diversity of rewards and reinforcement techniques in games is essential for finding an answer to the main research problem of this thesis. Accordingly, the first question is thus:

Q1: What types of rewards and reward techniques exist in games?

Because of the diversity of rewards and reward techniques in games, it can be challenging for developers to know what kind of reward to use in their games to create maximum motivation and hence increase continuous play. Therefore, the second question is articulated as follows:

Q2: What qualifies a good reward technique in games?

This question concerns greatly the aspect of human psychology and what is considered motivational in the designated target group - why some reward techniques are perceived as motivational and why others are not. Discussing

psychological theories is therefore seen as a necessity in this research in order to understand the characteristics of good rewards in addition to the variety of them.

Knowing how to apply rewards in games is perhaps equally important as the reward itself, and the third question is for that reason:

Q3: How can rewards in games be applied in the best way?

B. Educational components of the application

Even though the thesis should mainly focus on differences within rewards, reward techniques and how their differences impact users' motivation in the sense of preventing them from exiting the game, the project game developed should also raise awareness and knowledge to increase self-treatment skills in Type 1 Diabetes Mellitus. For this reason, the questions are:

Q4: What are most important behaviors required in self-management of Type 1 Diabetes Mellitus?

Q5: How can behaviors required in self-management of Type 1 Diabetes Mellitus be presented in a game?

1.3 Summary of Goals

Based on the sub-problems discussed former in Chapter 1, the goals of this thesis can be summarized as follows:

G1: The thesis should investigate what types of rewards exists in games.

G2: The thesis should cover how to apply reward techniques in games in the best manner.

G3: The thesis should explore the psychological background of rewards, motivation, and learning.

G4: The thesis should show how to design and implement a simple and attractive easy-to-play game for 8-12-years-old children.

G5: The thesis should describe a game providing Diabetes Mellitus knowledge and intestinally improve self-management skills for patients with the disease.

1.4 Assumptions and Limitations

Today, there are approximately 2.500 children under the age of 15 diagnosed with Type 1 Diabetes Mellitus in Norway (Diabetesforbundet, 2015). In other words, exclusively 0.05% of the Norwegian population fits the target group of this thesis. According to the Norwegian Childhood Diabetes Registry (NCDR) Annual Report 2015, 18 patients under age 18 are being treated for Type 1 Diabetes Mellitus at the University Hospital of North Norway (Skrivarhaug *et al.,* 2015). Based on this information, extending the relevant test-group by including children *without* Type 1 Diabetes Mellitus was found necessary to retrieve as many measurements as possible. Thus, broaden the experiment group was attainable as reward techniques in games applies to *all* children, regardless disease.

The target-group was decided to consists of children in age 8-12. This particular age-group was considered highly relevant as they have, up till now, been entirely dependent on their parents for disease management (Snoek & Skinner, 2005). Individuals in this particular age-group are often ready to learn self-treatment skills, and it is considered essential for making good habits from an early stage in life to prevent complications and facilitate good future health.

Perhaps the biggest and most severe limitation were constraints in time, with only one semester to complete the thesis. Therefore, I exclusively implemented some parts of the main idea of Diaquarium, and, unfortunately, had to leave the rest for future work. As a result, the implementation does not include

any reward techniques and only work as an early prototype to illustrate the main game mechanisms.

1.5 Methods

First of all, the idea of Diaquarium was conducted a late night while drawing for fun, and it was evident to me that the drawings could potentially become a game scenario. I had just finished my capstone project regarding rewards in serious games and found the topic very fascinating. I was curious how different in-game rewards could be applied in the Diaquarium, and potentially influence someone's behavior and motivation. I discussed the idea with my supervisor Hartvigsen as well as some of my colleagues, friends, and family. I also presented the idea along with the illustrations to the Diabetes Team at the Norwegian Centre for E-health Research, and they were all positive to the concept of the game.

I figured out the state-of-the-art in the field, searching for academic literature about serious games and rewards, as well as attempting to understand the psychological aspect of learning and motivation concerning reinforcements (which revealed itself to be incredibly complex).

After some improvements in the design, I started implementing the game. I realized that the design had to be improved additionally according to usability and for all the game objects to work smoothly together.

When I realized that I was not able to finish the game within the time constraints, I created a movie of the current prototype. Also, an anonymized questionnaire was set up for the test-group including the most important illustrations I made of the game concept, including different game scenarios with various rewards. The feedback retrieved from the questionnaire provided me valuable information concerning usability and preferred rewards the game, even though the game prototype was not completed.

Finally, the results from the questionnaire were analyzed.

1.6 Significance and Contribution

# Goal	Significance and contribution
G1	Relevant literature regarding different types of rewards in games has been reviewed and organized into a table. The project has addressed 35 different types/categories of in-game rewards, as well as 6 different game reward schedules.
G2	Knowing how to apply rewards in games is perhaps equally important as the reward itself. The reward schedules listed addresses how some rewards can be applied in games, as well as one researcher (Chou, 2013), who states how various rewards can be applicable. In addition, three serious games and their rewards have been addressed. Also, the Diaquarium discusses and explore how rewards can potentially be applied in the application in light of literature, discussions with experts, and feedback from potential users.
G3	There is little research on how different rewards influence motivation and behaviors of users playing serious games, or if rewards have any impact at all. Existing research mainly focus on how rewards affect learning (McKerna *et al.*, 2015; Howard-Jones & Jay, 2016), and not necessarily how they affect users in a motivational aspect. This thesis, therefore, enlighten the suggested missing research of serious games, in regard to how rewards affect users in gameplay in a psychological aspect. The thesis addresses one learning theory, in addition to three cognitive motivation theories that are highly related to games and reward in games.
G4	This thesis addresses the design process of a serious game, the Diaquarium, as well as implemented an early prototype of the respective educational game. The design has been described clearly and in detail. However, due to time constraints, the implementations has

	no significance to address and must be developed further in future work. *Figure 1. Early prototype of the Diaquarium*
G5	The Diaquarium demonstrates how Diabetes related knowledge can be applied in a game, where the relation between nourishment, blood glucose levels, and insulin is evinced through the game outline.

Table 1. Significance and contribution

1.7 Organization

The rest of the thesis is organized into the following chapters:

Chapter 2. Theoretical Framework. A theoretical overview of Diabetes Mellitus; its scope and costs, various types, the severity of poor medical care and possible complications, and self-treatment behaviors. Moreover, the chapter address a psychological aspect of human behavior according to motivation and learning. Lastly, an outline of serious games and different theories concerning in-game reinforcement techniques are presented.

Chapter 3. Materials and Methods. Explains research methods used in this project during development and implementation.

Chapter 4. Requirements and Specification. Discusses the requirements and specifications defined for this project.

Chapter 5. Design. Presents the overall design process of Diaquarium. It also describes the game content structure, including the differences concerning reinforcement mechanisms in both intentional versions of the game.

Chapter 6. Test and Results Gathers the feedback and findings from the questionnaires distributed to the projects test-group.

Chapter 7. Discussion Discuss and analyze the test and results in respect to the test and results. Crucial points and decision that was made throughout the project is also addressed.

Chapter 8. Conclusion and Future Work Conclusion remarks for this project. Also, suggestions for future work is acknowledged.

Chapter 2

Theoretical Framework

2.1 Basic Knowledge about Diabetes

Diabetes Mellitus is on the rise, appearing all over the world. In 2015, 415 million people were diagnosed with Diabetes Mellitus, a number that is expected to increase to 642 million people within 2040 (International Diabetes Federation, 2015). As Diabetes Mellitus has no known cure, patients depend on self-management treatment for the rest of their life to stay healthy. If the disease is not controlled correctly, it can lead to serious complications in health and well-being (World Health Organization, 2016).

The most severe consequence of inadequate care of Diabetes Mellitus is death, where the condition caused 1.5 million deaths in 2012 (World Health Organization, 2015). By the year 2030, it is predicted to become the 7th leading cause of death (World Health Organization, 2015).

Besides, Diabetes Mellitus and its complications cause a great economic burden for both people living with the disease, their families, health care systems, and national economics due to medical costs, loss of work and earnings (World Health Organization, 2016). In 2011, the global spending on healthcare for Diabetes Mellitus was $465 billion, e.g. 11% of the total healthcare expenditure (International Diabetes Federation, 2011). Many countries lack supportive environments and access to quality health care, indicating that the prevention and treatment of Diabetes Mellitus are not being practiced (World Health Organization, 2016).

There is no doubt why alternative methods and options for increased self-management tools in Diabetes Mellitus must be brought to our attention.

2.1.1 Definition of Diabetes

Diabetes Mellitus is a generic term used for a group of metabolic diseases caused by high level of glucose in the bloodstream (also known as hyperglycemia), together with a metabolism disorder of carbohydrate, fat, and protein, induced by a defect in production of insulin, use of insulin, or both (International Diabetes Federation, 2015; Levy, 2010).

Insulin is a hormone produced in the pancreas. Its main mission is to use the bloodstream to transport glucose absorbed from food to different body cells, where the body cell transduce glucose into energy. For people with Diabetes Mellitus, insulin is either ineffective or totally absent, meaning that the process of transporting glucose to body cells are not carried out. As a result, glucose remains in the bloodstream, causing serious damage to body tissues and gradually severe health complications (International Diabetes Federation, 2015).

2.1.2 Symptoms of Diabetes

There are various psychical signs and symptoms of Diabetes Mellitus, including thirst, polyuria, dry mouth, itchy skin, blurring of vision, hunger fatigue and weight loss (Levy, 2010; WebMD, 2016).

Bodies suffering from Diabetes Mellitus attempts to get rid of unused glucose in various ways when the insulin hormone is no longer transporting the blood glucose through the bloodstream as normal, for example through urine. Hence, the body requires extra fluids to produce the excrement, which endures to polyuria and thirst.

When the body produces increased amount of urine, the rest of the body suffers from dehydration, causing dry skin and dry mouth. Accordingly, change in body fluids can lead to swollen eye lenses and thereby change its shape, thus losing the ability to focus. As a result, blurred vision is known as a symptom for patients with Diabetes Mellitus.

Feeling hunger and tiredness is also a common symptom of Diabetes Mellitus, as the body cells are not receiving glucose as normal, and therefore cannot produce desired energy. (WebMD, 2016).

Because the symptoms are often mild or absent, patients tend to get problems from long-term damage caused by the disease because they are not diagnosed early enough (Levy, 2010).

2.1.3 Types of Diabetes

Diabetes Mellitus can be classified in four main categories; Type 1 Diabetes Mellitus, Type 2 Diabetes Mellitus, Other Specific Types, and Gestational Diabetes Mellitus (Holt, 2010).

2.1.3.1 Type 1 Diabetes Mellitus

Type 1 Diabetes Mellitus, also known as Insulin-Dependent Diabetes Mellitus (Couch *et al.,* 2008), is primarily caused by the body's immune system attacking and destroying β-cells in the pancreas, where β-cells produces insulin (National Diabetes Information Clearinghouse, 2014). Often some insulin resistance is also present as well (Holt, 2010).

When a β-cell is destroyed, it stops to produce insulin (Holt, 2010; National Diabetes Information Clearinghouse, 2014), thus the total insulin production in the body gets gradually worse. Respectively, when all β-cells have been damaged by the immune system, no insulin will be produced in the body evermore. The process begins well before symptoms appears and continues after diagnosis, consequently increasing risk of developing health complications as the human body depends on insulin treatment to survive (National Diabetes Information Clearinghouse, 2014).

Type 1 Diabetes Mellitus is usually diagnosed in children and young adults, and is the third most common chronic condition in young people (Gage *et al.,* 2004). The ailment is managed by insulin injection, a balanced diet and

exercise in order to maintain glycemic control and prevent severe health complications (Couch *et al.,* 2008).
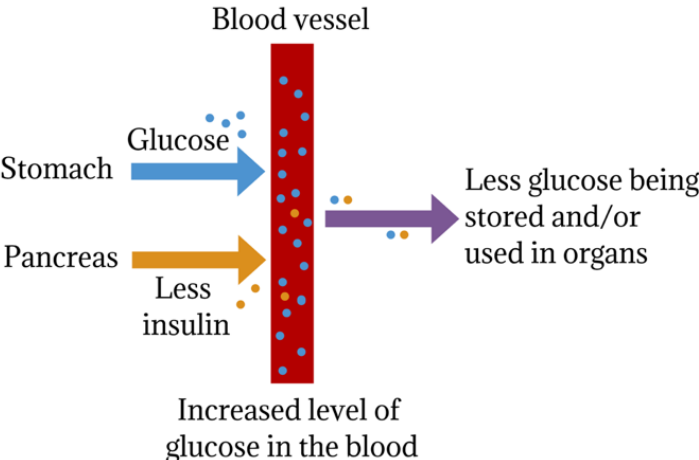
Figure 2. Type 1 Diabetes Mellitus, inspired by Winnipeg Regional Health Authority, 2016.

2.1.3.2 Type 2 Diabetes Mellitus

Type 2 Diabetes Mellitus, also known as non-insulin dependent mellitus (Couch *et al.,* 2008), is caused by insulin resistance with relative insulin absence (Holt, 2010). This means that the β-cells in the pancreas are able to produce the insulin hormone as normal, but the body develops insulin resistance, which disables insulin to transport glucose to body cells.
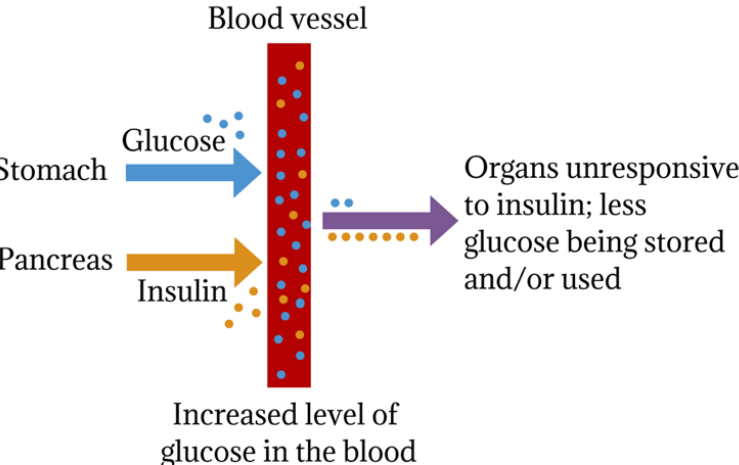
Figure 3. Type 2 Diabetes Mellitus, inspired by Winnipeg Regional Health Authority, 2016.

The disease is usually seen in adults, but occurs increasingly in children and adolescents (International Diabetes Federation, 2015). Compared to all types of Diabetes Mellitus, Type 2 Diabetes Mellitus is the most common on a worldwide scale. The precise molecular mechanisms causing Type 2 Diabetes Mellitus are not yet known, but the ailment is closely associated with obesity and physical inactivity (Holt, 2010).

2.1.3.3 Other Specific Types

Other Specific Types of Diabetes Mellitus are associated with monogenetic defects in β-cells function (American Diabetes Association, 2010). In these cases, Diabetes Mellitus occurs due to a specific genetic defect in insulin secretion and action, and in range of other conditions (Holt, 2010). Examples are genetic defects of β-cells function, genetic defects in insulin action, disease of endocrine pancreas, endorcrinopathies, drug- or chemical-induced, infection, uncommon forms of immune-mediated disease, and other genetic syndromes associated to diabetes (American Diabetes Association, 2010).

2.1.3.4 Gestational Diabetes Mellitus

Gestational Diabetes Mellitus occurs during pregnancy, where women develop elevated blood glucose levels during gestation (Holt, 2010, International Diabetes Federation, 2015). It usually appears from the 24th week of pregnancy, and normally cease after giving birth. According to American Diabetes Association (2010), approximately 7% of all pregnant women develop Gestational Diabetes Mellitus.

Being diagnosed with Gestational Diabetes Mellitus increases the risk of developing the disease again in following pregnancies, as well as Type 2 Diabetes Mellitus later in life (International Diabetes Federation, 2015). In addition, the children born to mothers who had Gestational Diabetes Mellitus during pregnancy

also have increased risk of developing Type 2 Diabetes Mellitus (International Diabetes Federation, 2015).

2.1.4 Complications of Diabetes

Diabetes Mellitus is a complex disease with increased chances of developing both acute and chronic complications in life, which can consequently cause many health problems for the patient.

Acute complications arise from uncontrolled high blood glucose (hyperglycemia) and low blood glucose (hypoglycemia), caused by either too much or too little diabetes medication (Diabetes Education Online, 2016). Some acute complications require immediate medical care, for example hypoglycemia, hyperglycemic hyperosmolar state, and diabetic ketoacidosis (Diabetes Education Online, 2016).

Years with consistently high glucose levels in the blood stream can cause chronic complications, leading to serious diseases affecting the heart and blood vessels, eyes, kidneys and nerves, as well as an increased risk of developing infections (International Diabetes Federation, 2015).
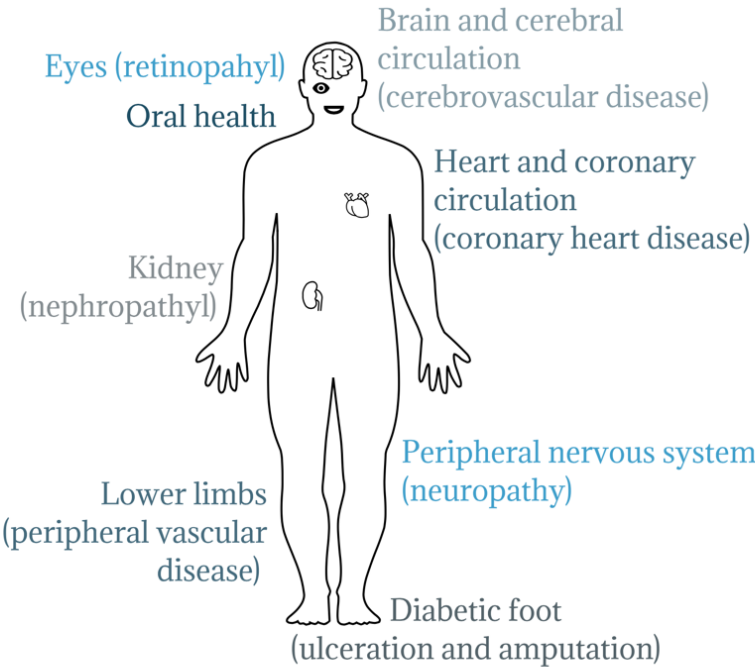
Figure 4. Diabetes complications

2.1.5 Management of Diabetes

Diabetes Mellitus cannot be cured, which heavily burdens individuals getting diagnosed and places high pressure on them to learn quality self-managing behavior in order to treat the ailment. The goal of self-management is to keep blood glucose levels, blood pressure and cholesterol levels as close to normal as possible (UCSF Medical Center, 2016; International Diabetes Federation, 2015).

The AAD Industry Allies Council (American Association of Diabetes Educators, 2016) have presented some self-management behaviors:

Figure 5. Self-management behaviors for patients with Diabetes Mellitus.

- *Healthy eating.* Making healthy food choices, understanding portion sizes and learning the best times to eat. A healthy meal plan should include complex carbohydrates, fiber, lean protein, lots of vegetables, a limited amount of heart-healthy fats.
- *Being active.* Regular activity is beneficial for weight management, lowering cholesterol, improving blood pressure, lowering stress and anxiety, and mood improvement just to mention some. In addition, being active can help

keeping blood glucose levels close to normal and thereby help keeping Diabetes Mellitus in control.

- *Monitoring.* Daily self-monitoring of blood glucose, blood pressure, urine ketones and weight can provide patients with Diabetes Mellitus the information they need to assess how food, physical activity and medications affect their blood glucose levels.

- Problem solving. Making quick correct decisions about food, activity and medications.

- *Reducing risks.* In order to manage diabetes in best way possible, effective risk reduction behaviors must be carried out. Such behaviors are quit smoking, having regular eye-, foot and dental examinations. Doing so will reduce diabetes complications and increase health and quality of life.

- *Healthy coping.* Health status and life quality is affected by physiological and social factors. Individual motivation to behavior change, setting goals and receiving support are all examples of healthy coping.

2.2. Psychological Framework

Children in age 8-12 are within a challenging stage of life. They experience different changes both physically and mentally, as they start to prepare to be independent survival adults. In this period of growth, they will enter a rapid maturation. Being diagnosed with Type 1 Diabetes Mellitus as well in this extent of time can be overwhelming for everyone affected. Family and friends must involuntarily adjust and cope with an unprepared situation when someone close has been diagnosed with the ailment. Especially parents are facing huge responsibilities considering medical care for newly diagnosed children in order to maintain the best possible condition and to avoid complications later in life (Streisand *et al.,* 2005)

A study done by Johnson *et al.* (1982) implies that youngsters' skill level regarding management of Diabetes Mellitus is poor, where evidence shows that they lack sufficient understanding of the disease to make accurate daily

management decisions. Providing quality age-appropriate knowledge regarding Diabetes Mellitus seems necessary both at diagnosis and throughout the patient's lifetime, where learning through educational games can potentially help children to adjust and cope better with their lifelong condition.

In addition, a brief research shows evidence that young people have a higher risk of developing complications in later life because of poor self-treatment. In 2005, Snoek & Skinner indicated that 28% of young adults don't obtain sufficient insulin to meet prescribed regimen. Later, Levy (2010) found that 85 % of all children and adolescents with diabetes had higher blood glucose levels than recommended, and only 6 % where within recommended targets. Holt (2010) states that irregular attendance to clinics correlates to poor glycemic control and a higher risk of diabetes-associated complications. Furthermore, Holt (2010) declares that young people with Type 1 Diabetes Mellitus are also more frequently diagnosed with and treated for psychiatric disorders, eating disorders, neurocognitive and learning problems, family dysfunction, and poor coping skills than the general population.

Developing quality serious games for children with Type 1 Diabetes Mellitus requires high knowledge and understanding regarding how human beings learn and how they are being motivated. The following sub-chapters therefore addresses some theories regarding learning and motivation in light of rewards.

2.2.1 Learning Theory

2.2.1.1 Reinforcement Learning

It is said that the nature of learning is interacting with our environment (Sutton & Barto, 2012) a statement everyone can relate to. As an infant, we wave our arms and feet, being curious about our surroundings. Each movement is guided by goals, such as grasping for food with our hands. Learning from action is claimed to be the foundational idea that nearly all theories of learning and intelligence found on (Sutton & Barto, 2012).

Reinforcement learning derives from this mindset, and is a theory concerning how individuals map situations to actions in order to maximize a numerical reward signal (Doya, 2007). Lee *et al.* (2012) describes reinforcement learning as an adaptive process in which a learner utilizes its previous experience to improve the outcome of future choices. Reinforcement learning can therefore be said to explore the optimal way to make a decision. For that reason, reinforcement learning sits in the intersection of many different fields of science (Doya, 2007; Silver, 2015), as illustrated in the venn-diagram (figure 6) derived from Silver (2015).

Reinforcement learning has no explicit teacher telling the learner what to do. Instead, the learner must by itself figure out what actions leads to the most reward by trying them out (Doya, 2007). Actions does not only affect the current reward, but also the next situation and thereby the following rewards. The learner may therefore not know the outcome of a decision made until several steps later (Doya, 2007; Silver, 2015). Therefore, making the best choice may require some foresight or planning, but at the same time, actions cannot be fully predicted; meaning that the learner must monitor the environment frequently and adjust its reaction (Doya, 2007). The trial-and-error search and delayed reward characteristics are, according to Doya (2007), the most important features of reinforcement learning.
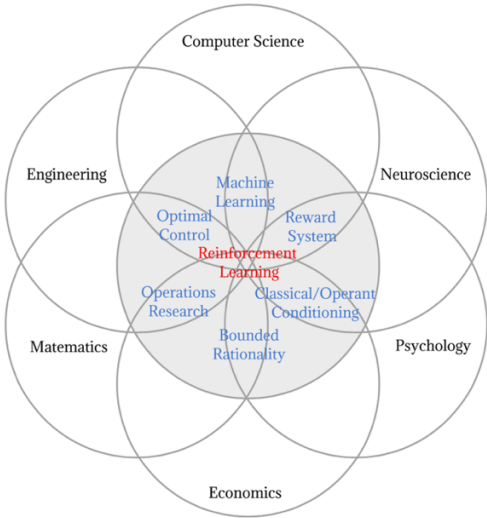
Figure 6. Reinforcement Learning and Different Fields of Science (Derived from David Silver, 2015)

2.2.1.1.1 Elements of Reinforcement Learning

There are six main elements of the reinforcement learning system, addressed by Sutton and Barto (2012).

The first element is termed the *agent*, also known as the learner and decision-maker. Agents can be animals, humans, or artificial systems (Doya, 2007).

The second element is called the *environment,* which is everything outside the agent that the agent is interacting continually with (Sutton & Barto, 2012). It is through the environment that the agent makes decision about actions, where the environment responds by presenting a new situation for the agent in relation to the selected action.

The third element is known as *policy*. A policy maps the environment to upcoming actions for a particular state in order to determine how agents behave (Sutton & Barto, 2012).

Next, the fourth element in reinforcement learning is the *reward function.* Reward function maps each observed state of the environment to a reward, and can therefore say something about good and bad events for the agent. Sutton & Barto (2012) defines this element as the goal in reinforcement learning. In addition, a reward function could possibly adjust the policy element. For example, if a policy resulted in a low reward, the policy may change in the future in order to select another action for that particular situation in order to avoid the low reward (Sutton & Barto, 2012).

The following element specifies the long-term desirability for states, known as the *value function.* It differs from the reward function element, as it considers states that are likely to follow and the rewards within those states, and not just the immediate good rewards for a current state (Sutton & Barto, 2012). This means that one state can yield low immediate reward, but in the long run, choosing that particular state could possibly lead to higher reward function (high value function), or the other way around. Values must therefore be estimated from the sequence of observations the agent makes over its entire lifetime (Sutton & Barto, 2012).

The last element can be seen as optional, as it is a *model of the environment.* A model mimics the behavior of the environment, predicting the result for next state and next reward according to a given state and action (Sutton & Barto. 2012). Not all reinforcement learning systems uses models, but when they are applied, they are usually used for planning since they consider possible situations before they are experienced (Sutton & Barto, 2012). This will be further addressed in sub-chapter 2.2.1.1.3 below.

2.2.1.1.2 The Agent-Environment Interface

In order to understand reinforcement learning, a closer look at the agent-environment interface is necessary. The agent and environment relates through steps in time, t = 0,1,2,3, … For each step t, the agent receives a representation of the environment state, denoted by $S_t \in \mathcal{S}$, where $\mathcal{S}$ is the set of possible states in the respective environment (Sutton & Barto, 2012). Next, the agent selects an action $A_t \in \mathcal{A}(S_t)$, where $\mathcal{A}(S_t)$ is he set of possible actions available for that particular state S_t (Sutton & Barto, 2012). One time step later, the agent finds itself in a new state S_{t+1} and receives a numerical reward, $R_{t+1} \in \mathbb{R}$, as a consequence of its action (Sutton & Barto, 2012). See figure 7 for further illustration of this interface.

Since the agent's goal is to maximize the total amount of reward it receives in the long run (Sutton & Barto, 2012), the expected cumulative future reward can be declared as

$$E[reward(t) + \gamma reward(t+1) + \gamma^2 reward(t+2) + \cdots], \text{(Doya, 2007)}$$

where E[] represents the expected average value and parameter γ denotes how far into the future the agent concerns. This declaration illustrates how complex reinforcement learning is, as an action(t) does not only affect the immediate reward(t), but also the next state(t+1), which affects the availability of future rewards (Doya, 2007).

This framework is abstract and flexible (Sutton & Barto, 2012), and can therefore easily be applied for different problems, such as the Diaquarium (see Figure 8). A child (agent) makes an action by clicking on a goldfish (state) with a computer mouse, whereas the computer (environment) receives the input and transmits consequently a new state of the goldfish along with an immediate reward for that particular action.
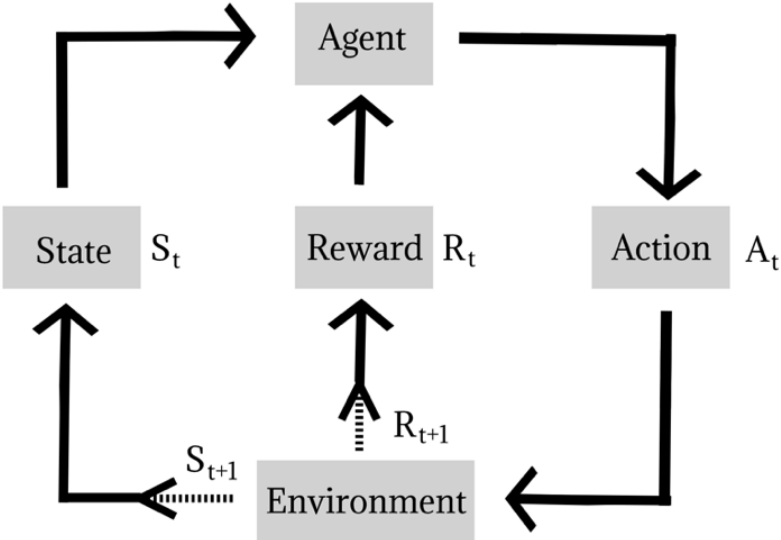
Figure 7. The agent-environment interaction of reinforcement learning (Based on illustration from Sutton & Barto, 2012)
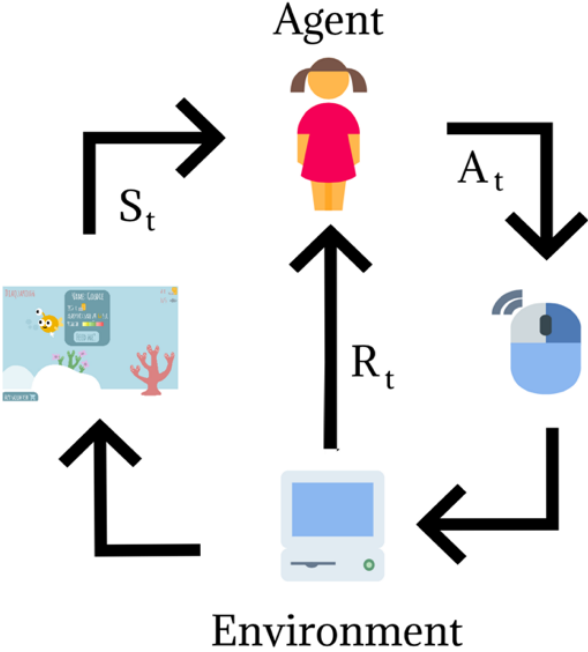
Figure 8. The Diaquarium reinforcement learning scenario

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2.2.1.1.3 Model-Based vs. Model-Free

There are at least two systems for learning about reward, punishment, and predictions for actions in reinforcement learning (Dayan & Berridge, 2014); the model-based system and the model-free system.

For model-based system, a cognitive model is used to search the next good action. The strategy is goal-directed, where the internal model supports prospective assessment of the consequences of taking particular actions (Dayan & Berridge, 2014). It uses representations of the environment, expectations, and prospective calculations to make cognitive predictions of future value (Dayan & Berridge, 2014). To explain this further, an example is presented (an example inspired by Dayan, 2011). A rat is trained to press a lever in order to get cheese, where the experiment differs between short and long training sessions. The cheese is then devaluated by adding something to the cheese that makes the rat ill. The rat will therefore pair the cheese with illness. For short training, the rat did some simple cognitive mapping; pressing the lever provides cheese, but the cheese made the rat sick, so the rat decides not to push the lever. If the rat was trained extensively, the rat pushed the lever even though he knew the cheese would make him sick. The lever was pushed and the cheese was not eaten. This kind of system provides you an instant feedback; if you press the lever you will get cheese, if you don't push the lever you will not get cheese. This means that learning is entirely relying on experienced reward (Lee *et al., 2012*).

The model-free system, on the other hand, doesn't use any model to search for the next good action. Instead, the system works by minimizing inconsistency. To exemplify, making a move in chess could possibly make you win. But when your opponent makes his next move, your position can potentially make you lose. The action that was beneficial one time step earlier is now not beneficial anymore. The fact that there is an error between those two means that there is an inconsistency that can be used in training (Dayan, 2011). The agent must therefore do some future prediction, and learn by prediction-error signals. A reward prediction-error is referred to the difference between the actual reward and the reward expected by

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the current value functions (Lee *et al.,* 2012). Previous experiences are cached progressively for long-run values of circumstances and actions from retro perspective experience (Dayan & Berridge, 2014). Individuals using model-free system do not make predictions based on data or quality information, but rather learn as they go (Dayan, 2011).

According to Dayan & Berridge (2014), model-based systems have been used to produce cognitive or flexibly goal-directed instrumental behavior, whilst model-free systems are often used to produce automatic instrumental stimulus-response habits.

2.2.2 Motivation Theories

There are many different approaches regarding motivation in psychology, all interested in what moves people to act. Motivation is therefore important for learning (Yoo *et al.*, 2012). When designing video games for health, the main attempt is to modify some aspects of their health behavior and behavioral change (Komulainen, 2016). However, behavior processes are complex and influenced by different factors, such as motivation.

This thesis will only address a few of the cognitive motivation theories that was considered beneficial for this thesis, where cognitive psychology studies mental processes, including perception, thinking, memory and judgements (Stangor, 2011).

2.2.2.1 Cognitive Motivation Theories

Before looking into cognitive motivation theories, there are two main motivations systems that must be addressed first that some of the respective theories derive from; intrinsic and extrinsic motivation.

Intrinsic motivation is the terminology of someone being engaged in a task for the inherit reward, such as interests and enjoyment. In other words, intrinsically motivated individuals are therefore moved to act for the fun or

challenge (Ryan & Deci, 2000). *"Intrinsic motivation is typically viewed as the determinant of behaviors performed for their own sake"* (Kanfer, 1990).

Extrinsic motivation, on the other hand, occurs if the reward is outside the individual, such as grades or toys. In other words, individuals are motivated to do something because it leads to a separable outcome (Ryan & Deci 2000). *"Extrinsic motivation is our tendency to perform activities for known external rewards, whether they are tangible or psychological in nature"* (Brown, 2007).

Ryan and Deci (2000) suggests that the relationships between extrinsic and intrinsic motivators is interconnected, which means that individuals can experience different grades of both motivations at the same time. To exemplify; individuals are high on intrinsic motivation because they love to play tennis, but are also high on extrinsic motivation because it helps them to stay active and healthy. Other individuals love to play video games and is therefore high on intrinsic motivation, but they don't get anything out of the gameplay itself, and is therefore low on extrinsic motivation.

In educational context, evidence have shown that intrinsic motivation is correlated to increased learning, and that extrinsic motivation can have negative effects on intrinsic motivation (Ryan & Deci, 2000; Deci & Ryan, 2012).

2.2.2.1.1 Self-Determination Theory

In 1985, Ryan & Deci (2000) addressed the Self-Determination Theory. This cognitive motivation theory distinguishes between various types of motivation, and the aim based on different reasons or goals that results in an action (Ryan & Deci, 2000). There are three psychological needs that Self-Determination Theory states people have – autonomy, competence, and relatedness, where autonomy is the feeling of being origin of one's own behavior, competence is the feeling of being effective and good at something, and relatedness is felling understood and cared for by others (Silva *et al.*, 2014). These tree needs are universal and, according to this theory, important for psychological growth, integrity and wellbeing (Ryan &

Deci, 2000). In order to have intrinsic motivation, all three needs must be met (Ryan & Deci, 2000).

If a reward or other external event such as thread of punishment, positive feedback, competition, or choice were expected to thwart these basic needs, it was predicted to prompt an external perceived locus of causality and undermine intrinsic motivation; but if the event were expected to support these basic needs, it was predicted to prompt an internal perceived locus of causality and enhance intrinsic motivation. Monetary rewards, threats, and competition were predicted to thwart autonomy, and such events did typically undermine intrinsic motivation. In contrast, positive feedback and choice were predicted to enhance experience of competence and self-determination, fostering greater intrinsic motivation, and results have confirmed this as well." (Deci & Ryan, 2012).

2.2.2.1.2 Expectancy Value Theory

Expectancy Value Theory is addressing achievement behaviors and is characterized by individuals' expectancies for success and the value they have for succeeding, such as individuals' beliefs about how well they will do on an upcoming task (Wigfield, 1994; Wigfield *et al.,* 2009). This means that *"if more than one behavior is possible, the behavior chosen will be the one with the largest combination of expected success and value"* (University of Twente, 2016). The conceptual expectancies for success is, however, distinguished from the individuals' beliefs regarding competence or ability (Wigfield *et al.,* 2009).

Expectancy Value Theory "asserts that the amount of effort that people are willing to expand on a task is the product of (a) the degree to which they expect to succeed at the task, and (b) the degree to which they value the task and value success on the task" (Green, 2002).

2.2.2.1.3 Achievement Goal Theory

According to Achievement Goal Theory, goals gives an activity purpose or meaning, where the theory specifies what kind of goals that direct achievement-related behaviors (Maehr & Zusho, 2009). Achievement goal theory does not concern with what individuals are trying to achieve (for example, my goal is to get better self-treatment skills in Diabetes), but instead focus on understanding why (for example, why would my goal be to get better self-treatment skills in Diabetes?) (Maehr & Zusho, 2009). *"Learners tend to engage in tasks with concerns about mastering content (mastery goal), doing better than others (performance-approach goal) or avoiding failure (performance-avoidance goal). Mastery goals appear to stimulate interest and deep learning, whereas performance-approach goals are associated with better grades. Performance-avoidance goals are associated with less favorable outcomes. Mastery orientation refers to a focus on getting smarter or better; it emerges from an 'incremental' or growth learning mindset (ability is malleable, situations are controllable). Performance orientation refers to a focus on looking smart and not looking dumb; it emerges from an 'entity' learning mindset (ability is fixed, situations are less controllable)"* (Cook & Artino, 2016).

2.3 Serious Games

Serious games have been used for educational purposes in various health context for the last decades, where the term "serious game" was first mentioned by Clark C. Abt in 1968 (Engler, 2012). From then on, there have been many different definitions of serious games, but most agree on the core meaning that serious games have a primary purpose other than entertainment (Abt, 1970). In other words, educational games should provide some knowledge that can be useful in real life (Engler, 2012).

The purpose of serious games can be denoted as twofold; it should be (i) educational, as well as (ii) fun and entertaining (Bellotti *et al.,* 2013). Developing serious games should therefore take these two aspects in close consideration

(Lewis, 2007) in order to create a successful game design (e.g., an effective game outline for the target audience).

2.3.1 Rewards in Games

According to Brian McKernan *et al.* (2015), game scholars generally defines a reward as *"any game item or feature that reinforces particular in-game behaviors"* (Brian McKernan *et al.,* 2015), and that this form of behavior reinforcement may motivate players to continue game-play (Brian McKernan *et al.,* 2015). Similarly, Phillips *et al.* (2013) defines rewards in games as *"a positive return that serves to reinforce player behavior within a video game"* (Phillips *et al.,* 2013). Schell (2008) described rewards as a type of feedback, or *"the way the game tells the player "you have done well""* (Schell, 2008). Rewards have three fundamental functions on individuals; (i) they evoke learning as they make individuals come back for more, (ii) they induce approach and consummator behavior for acquire the reward object, (iii) they stimulate subjective feelings of pleasure and induce positive emotions (Schultz, 2000; Schultz, 2004).

Howard-Jones and Jay (2016) studied the link between reward and learning in the context of reinforcement learning. They claim that the term "reward" differs in meaning within circumstances of education and cognitive neuroscience. *"In an educational context, rewards are usually material offerings or social symbols of recognition intended to influence behavior, and motivation can include the desire to reach long-term goals. In cognitive neuroscience, rewards include both material and social reinforces, and motivation as being associated with positive and negative affective states or stimuli, and more often with short-term behaviors that may include approach or withdrawal from stimuli."* (Howard-Jones & Jay, 2016).

Howard-Jones and Jay (2016) proposes that rewarded actions can potentially influence the cognitive function in video games. When the brain receives a better-than-expected reward, the reward learned associated produces a change in reward-seeking behavior that helps to optimize the individual behavior (Howard-Jones & Jay, 2016). Howard-Jones and Jay (2016) refers to studies that

have suggested that the variance or uncertainty of possible rewards, based on the expected value of previous rewards, may influence dopamine levels in the brain, producing a sustained raise between the cue that the reward may occur and the actual deliver of the reward. Users can for example be offered the chance to win a reward through some random mechanisms, e.g. a wheel of fortune or toss a coin (Howard-Jones and Jay, 2016) in return for successfully completing a challenge within the game. *"Dopamine release from the midbrain is thought to play an important role in learning to associate rewards and actions in reinforcement learning, and such release can also enhance declarative memory formation."* (Howard-Jones & Jay, 2016). It is therefore suggested that introducing uncertainty regarding rewards can possibly increase motivation, due to the correlation between sustained raise of dopamine activity, cue prediction that a reward may or may not arrive, and revealing of outcome (Howard-Jones & Jay, 2016).

Games that are highly engaging offers schedules of rewards for preforming many correct actions in a row. Howard-Jones and Jay (2016) rephrases research done by Adcock *et al.* that suggests that reward motivation promotes declarative memory formation. A study done by Ozelik *et al.* (Howard-Jones & Jay, 2016) tested two groups of students in a virtual educational game, where one group received points for correct answers, while the other group gained a number of points determined by chance for correct answers. Results showed that the students in the uncertain condition achieved greater improvements in performance than the other group (Howard-Jones & Jay, 2016).

Brian McKernan *et al.* (2015) designed two educational games with and without the range of reward features, and then examined learning outcomes. The results suggested that both games improved learning, but the quantity of in-game rewards did not have an impact on behavior or knowledge. They also examined the perception of feeling rewarded, and found that those who were rewarded had more favorable views of the gameplay experience, but it did not differ in the learning outcome. Brian McKernan *et al.* (2015) implies that the perception of feeling rewarded and the in-game reward features themselves should be distinguished.

The two last decades, various fields have explored the features of video games and used them as powerful educational tools (Brian McKernan *et al.,* 2015).

This work has identified rewards in games as an important source to the overlay appeal to video games, and some have suggested that the reward systems found in games should also be applied in educational games (Brian McKernan *et al.,* 2015).

Brian McKernan *et al.* (2015) refers to two separate, but interrelated reasons why educational games should include reward systems according to scholar literature. *"First, scholar suggests that rewards may strengthen learning outcomes by motivating individuals to pursue challenging tasks or goals that they otherwise would be less in interested in or attempt less diligently"* (Brian McKernan *et al.,* 2015). In other words, in-games features that players finds appealing may motivate them to both continue to play the game and to play the game more carefully than they would in another way (McKernan *et al.,* 2015).

"Second, many game-based learning scholars treat certain in-game rewards as providing a valuable form of performance feedback." (McKernan *et al.,* 2015). Positive verbal feedback has appeared as motivational in order to continue a task while feeling competence and increased self-determination (McKernan *et al.,* 2015).

In general, the majority of scholars consider some reward mechanisms to be important components to game-based learning (McKernan *et al.,* 2015). The fundamental principles of quality game design are, according to McKernan *et al.* (2015), *"providing players with a meaningful sense of control over the actions and challenges that are progressively difficult without being unfair"* (McKernan *et al.,* 2015). McKernan *et al.* (2015) suggests that these perceptions of autonomy, challenge, and control may allow a game to feel rewarding to players even though in-game rewards are minimal or not present at all. The result in their research implies that learning is not affected by the quantity of reward features in an educational game. When they examined how perceptions of feeling rewarded, receiving rewards, and receiving praise influenced these results, they found that feeling rewarded was not related to the quantity of reward features in the game. They explained it as players perhaps felt rewarded more by the core features of the game than in-game reward features, and suggested that players feel more rewarded when they like a game. This theory is supported by theories considering intrinsic motivation, claiming that individuals are intrinsically motivated to

engage in a task or activity when they find the activity itself to be pleasurable or enjoyable (McKernan *et al.*, 2015).

2.3.1.1 Types of Rewards in Games

There are many different types of rewards in games, but there has been limited empirical research with regard to the classification and types of video game rewards (Phillips *et al.*, 2013). Thus, there have been an attempt to make an overview of some types/categories of rewards found in the literature search. The results are presented in Table 2 below.

Resource	Type of Reward/ Category	Description
Hallford & Hallford, 2001	Rewards of glory	Rewards that are associated with prestige and self-affirmation, but make no difference to the game-play, for example finishing a level or bearing a particular tricky opponent.
	Rewards of sustenance	In-game items that enhance or prolong the game, so that the player can maintain their avatar's status and keep possession that they have gained into the game so far, such as medicine packs that restore health or extra lives.
	Rewards of access	The ability to access new locations or resources within the game.
	Rewards of facility	The ability to do things that the player or player's avatar could not do before. Such as learning a new spell to become

		more powerful, or an extra-game, such as unlocking a new mini-game.
Oxland, 2004	Game-play rewards	The most important gameplay reward of all, given to the players for completing challenges, performing actions successfully, achieve goals etc. The actual reward can be many things, but the main reason is to assist the player for progress in the game.
	Hidden rewards and secrets	The reward could be anything, but should give the player something that he's not expecting or something that he regards as "cool" but has limited use or limited life-span. Examples of these kinds of rewards are objects like discovering a secret room behind a mirror, or a shortcut within the gameplay.
	Impetus rewards	Rewards that pulls the player towards a particular goal, such as solving a puzzle or reaching an object that is currently unobtainable. When the player reaches the goal, he is rewarded.
	Visual rewards	Visual treats as rewards, such as big explosions, special effects and things that the player has never seen in the game before.
Schell, 2008	Praise	The game telling you that you have done well, through words, sounds or an in-game character talking.

		Points	Either as a measurement of success, or as a pathway to other rewards.
		Prolonged play	The ability to play longer by providing increased play time, extra health or an extra life.
		A gateway	Entry to new parts of the game that can be explored.
		Spectacle	Beautiful or interesting music, animation or sight.
		Expression	The ability for the player to make a mark on the world, through access to special clothes or items.
		Powers	New or improved skills or abilities that allow the player to achieve things in new and better ways.
		Resources	Virtual resources that can be used in the game, or virtual money that can be spent.
		Completion	The feeling of closure gained from completing the game.
King et al., 2009	General reward types	• Physical force feedback (e.g., vibration in a car racing game) • Reward the player with in-game currency (e.g., gold coins) • Points that usually occur without being converted or exchanged into some other kind of reward • Experience points as the complete objectives and defeat enemies • Earn assorted items and upgrades

		• Fulfilling a video game's objective within certain game parameters to unlock bonus game content
	Meta-game reward features	Designed to give players an overall assessment of their mastery over a video game, for example by showing a single percentage rating that indicates how much of the game the player has completed. The purpose of this feature is to encourage the player to continue playing until total completion is reached. Research has shown that meta-game features often set large goals for the players, keeping them playing longer than intended and contribute to the belief that no amount of time is enough.
	Intermittent reward features	This feature suggests that a player is rewarded for playing video game is more important than the rewards themselves. According to conditioning theory, video games can reinforce correct or skillful play on variable and fixed ratio reinforcement schedules. This type of reward can sustain player's motivation to play for longer periods, because the next reward is "just around the corner".
	Negative Reward features	Negative reinforcement techniques can keep players involved in unwanted or unpleasant situations. For example, when injured in a shooting game, "health" statistic on the "heads up

		display" (e.g., 65%) are often presented. By finding items that will increase the character's health (e.g., bandages, medicine), the unwanted character state is removed and the player feels a sense of relief.
Wang & Sun, 2011	Score reward system	This type of reward uses numbers to mark player performance. Scores serve as tools for self-assessment and comparison.
	Experience point reward system	During game play, avatars can "level up" when specified goals are achieved. Experience point rewards are often given in the form of new skills, or perhaps increase attributes like strength or intelligence. This system is bound to specific avatar, and reflect time and effort rather than player skill. It affects the game directly, as it can make tasks easier to accomplish and can expand ways the game can be played. It creates a feeling of progress and achievements.
	Item granting system rewards	Usually consist of virtual items that can be used by players or avatars. Item granting systems encourage exploration of game worlds, and are often used between exciting moments in the game. It is known that some players devote a lot of time and sometimes even real money to grant rare types of items,

			making this mechanism an important concern when designing games.
		Resources	Resources are valuables that can be collected and used to affect gameplay. Resources and items differs, as resources are mostly for practical game use or sharing, whereas items have a collecting and social comparison value.
		Achievement systems	By fulfilling clearly stated conditions, players can collect titles bounded to their avatar or player account. This system encourages players to complete tasks, play in challenging ways, or explore game worlds.
		Feedback messages	Provides an instant reward. Its purpose is to create positive feedback that players receive in response to successful actions and to create positive emotions. One example is the word "perfect" shown on screens when players hit the correct button with precise timing. Other examples of feedback mechanisms are pictures, sound effects and video clips. Since they are ephemeral, they are not collectable nor available for player comparison, and do not directly affect the gameplay.
		Plot animation and pictures	Rewards following up important events, like for example when defeating a major enemy or clearing a level. Their purpose is to motivate players to advance game

		stories. This type of reward provides sense of fun displaying animations and pictures players find attractive, and also serve as a milestone marking players achievement.
	Unlocking mechanisms	Gives access to game contents when certain requirements are met, like for example new levels, special virtual environments, mini-games etc.
Chou, 2013	Fixed Action Rewards	Also known as earned lunch. The user known exactly what he/she must do to get the reward.
	Random Rewards	Also known as mystery box. The participant gets a reward based on completing a required action, but they don't necessarily know that the reward is. This actually doesn't matter and can even enhance their engagement; the process of getting the reward is exiting because the participant knows that they will be surprised at the end by whatever they and up with.
	Sudden Rewards	Also known as Easter Eggs. Rewards that are not known and the player doesn't expect to get for taking a specific action. Players love the element of surprise and the bonus feeling of excitement and luck, because the reward was so unexpected.

	Rolling Rewards	Also known as lottery. Rewards that are given to a select amount of winners by chance after they take a specific action.
	Social Treasure	Rewards that are given to you by your friends. You can't buy them; you can't earn them; you can only get them if someone else gives them to you. Helps spread the word-of-mouth because it forces you to get your friends involved.
	Pricing Pacing	Rewards that are given out a small piece at time. Players have to collect the pieces to earn their reward.

Table 2. An overview of rewards in games

2.3.1.2 Reward Schedules in Games

Some researchers argue that it isn't the reward itself that is the most important part when applying rewards in games to reinforce behavior, but rather the timing when players anticipate and receive rewards (as discussed in chapter 2.3.1). In this subchapter, various reward schedules in games will be presented, where the main task of reward schedules is to yield rewards in games.

2.3.1.2.1 Fixed Reward Ratio Schedule

A fixed ratio schedule hands out in-game rewards in a systematic order, e.g., the ration between action and rewards is always permanent (Sylvester, 2013). An example to a fixed reward ratio schedule is a player receiving gold each time he/she defeats an enemy in gameplay. However, the ration doesn't need to be one-to-one, e.g., players can receive 10 gold pieces for every 10th enemy defeated (Sylvester, 2013).

Figure 9. Illustration of Fixed Reward Ratio Schedule

2.3.1.2.2 Variable Reward Ratio Schedule

Variable reward ratio schedule changes every time rewards are given (Sylvester, 2013), e.g., the schedule usually yields rewards after a random number of actions. An example of variable reward ratio schedule is players having 10% chance of receiving 10 gold coins for each defeated enemy in gameplay. As a result, players can receive rewards three times in a row, while other times they have to defeat 50 enemies before they are rewarded.

Figure 10. Illustration of Variable Ratio Schedule

2.3.1.2.3 Fixed Interval Reward Schedule

In fixed interval reward schedules, rewards are available a fixed time after another reward. This means that if the reward was a health pack, it will be unavailable in 5 minutes after it was taken, at which point it can be grabbed again (Sylvester, 2013).

Figure 11. Illustration of Fixed Interval Reward Schedule

2.3.1.2.4 Variable Interval Reward Schedule

The variable interval reward schedule makes rewards available after random time after one is taken.

Figure 12. Illustration of Variable Interval Reward Schedule

2.3.1.2.5 Differential Reinforcement of Low Response Rate Schedule

The differential reinforcement of low response rate schedule is very similar to the fixed interval schedule. The difference is that when players' attempts to get a reward to early, the interval restart the process of providing rewards.
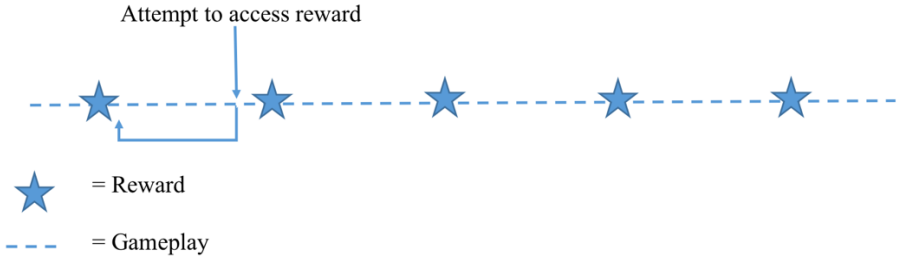

Figure 13. Illustration of Differential Reinforcement of Low Response Rate Schedule

2.3.1.2.6 Differential Reinforcement of High Response Rate Schedule

The differential reinforcement of high response rate schedule demands players to do certain amount of activity within a given interval in order to receive the reward. To exemplify the scheduler, a player must defeat five enemies within one minute in exchange for a reward.

Figure 14. Illustration of Differential Reinforcement of High Response Rate Schedule

2.5 Rewards in Related Serious Games

2.5.1 The Diabetic Dog Game

The Diabetic Dog Game is a serious 2D game created by Nobel Web AB (2010), and is, as the name implies, a game where users must care for a dog with Type 1 Diabetes Mellitus. The dog is affected by its blood glucose levels, insulin, and other parameters such as mood, where the player must make decisions and actions accordingly. The main goal of the game is to take care of the dog and make sure it is happy and healthy by granting love and affection, arrange walks, provide food, and supply insulin.

Reward in The Diabetic Dog Game is primarily money. After each day as a caretaker, users receive an evaluation regarding how well they managed to take care of the diabetic dog for that respective day. It mainly estimates how adequately the user took care of the dog in a health and attention perspective, in addition to a standard salary handout.

The money earned from each evaluation is added to a cash on hand feature, which can be used in the shop. Users can buy different food items to feed the dog from the shop, as well as a number of special items, such as bowls and dog houses.

In addition, special items in the shop can be considered to be rewards. These items are being associated with prestige and expression, but makes no difference

64

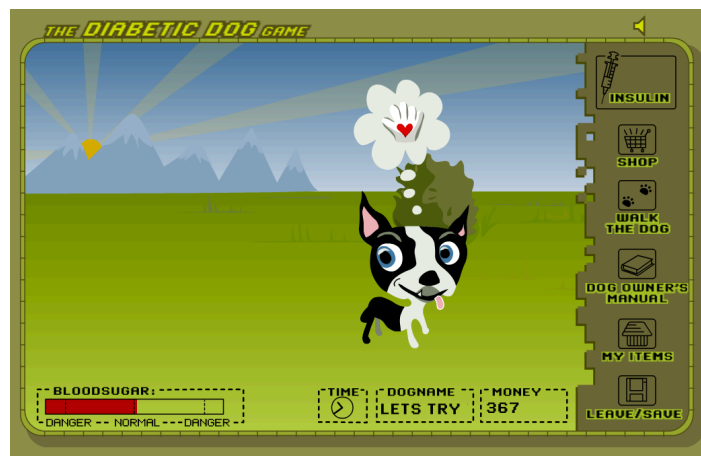in the game play. Also, the emotions of the dog (mood) can be seen as a feedback type of reward.

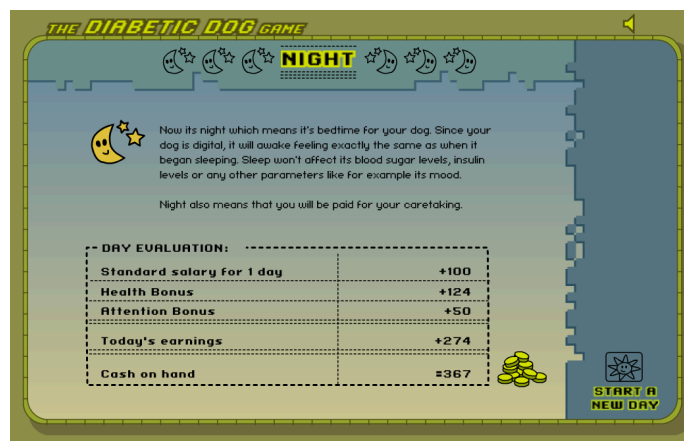*Figure 15. The Diabetic Dog Game (Screenshot)*

Figure 16. Reward in The Diabetic Dog Game (Screenshot)

Figure 17. Food items in the shop (Screenshot)

65

Figure 18. Special items in the shop (Screenshot)

2.5.2 Carb Counting with Lenny

Carb Counting with Lenny, produced by Medtronic (2011), consists of four different mini-games with the same goal – increase knowledge regarding carbohydrate content in various food groups. The games are Carb or No Carb, Compare the Carbs, Guess the Carbs, and Build a Meal
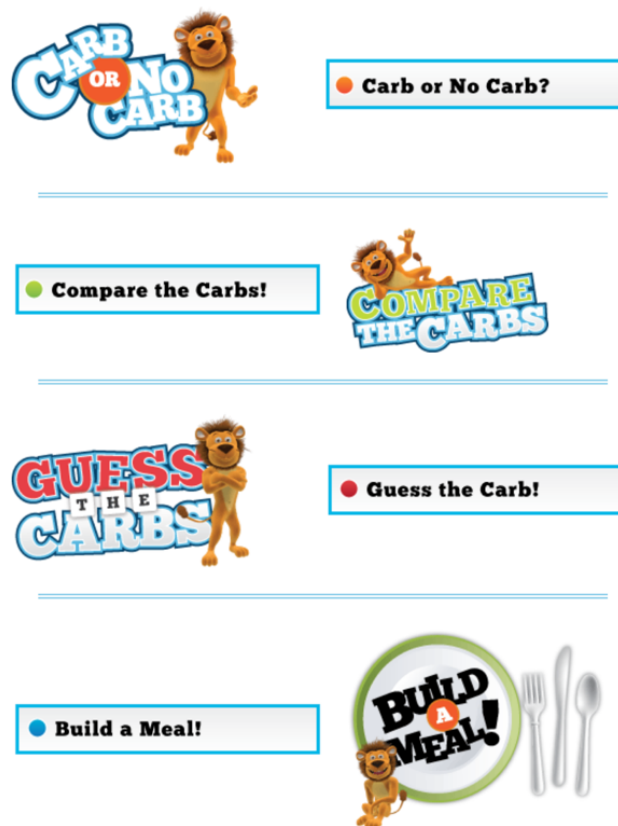

.

Figure 19. Four mini-games in Carb Counting with Lenny (Screenshot)

All four mini-games practices the same reward mechanisms which is constant feedback messages such as "great job!" and "correct" combined with a sound signal. In addition, correct answers are rewarded with points in a score system related to how fast the user is able to answer accurate. Fast correct replies are rewarded with high points.

2.5.3 Ketones Attack

Ketones Attack is an asteroid game hosted by Juvenile Diabetes Research Foundation (JDRF, 2010). The game outline is to take care of a diabetic avatar and its respective blood glucose by shooting sugar cubes or ketones. The game exists with several levels of rewards.

Figure 20. Ketones Attack (Screenshot)

Firstly, the game exists with a score interface that counts defeated sugar cubes and ketones. Medium and large sized cubes are worth 10 points each, whilst the smaller sugar cubes are worth 110 points each.

Secondly, the player is rewarded with ammunition if they manage to collect insulin during playtime.

In addition, special insulin packets appear on the screen occasionally. When collected, the player is rewarded with super health which implies that the avatar cannot be hurt by sugar cubes or ketones during its active time. However, special

insulin packets only work once, so users must do some planning for when they are going to benefit from one.

Lastly, the 20 best scores of all users who ever played the game is rewarded with a public display on a high score list.

2.6 Summary

This chapter provides basic knowledge about Diabetes Mellitus, its scale, and self-management behavior to regulate the disease in order to stay healthy. Also, psychical learning and motivation theories has been discussed, which are applied during the design process of the applications environment. Further, theory regarding different types/categories of rewards, reward schedules, and reward applied in related serious games has been addressed, which provides the background in respect to designing some of the in-game rewards in the Diaquarium.

Chapter 3

Methods and Materials

This chapter explains clearly how the thesis was conducted.

3.1 Research Paradigm and Tools

The problem scope of this thesis was understood and addressed with an engineering approach, where the project was conducted with an iterative and incremental development of the steps illustrated in Figure 21. This means that the actual implementation wasn't started until the game design was completed and had gone through state requirements and state specifications. These steps were addressed by the researcher Denning and his colleagues in 1989 (Computing as discipline), and arranged in a figure by the author of this thesis. These steps are iterated as long as the tests reveal that the latest version of the systems does not meet the requirements (Denning et al., 1989).
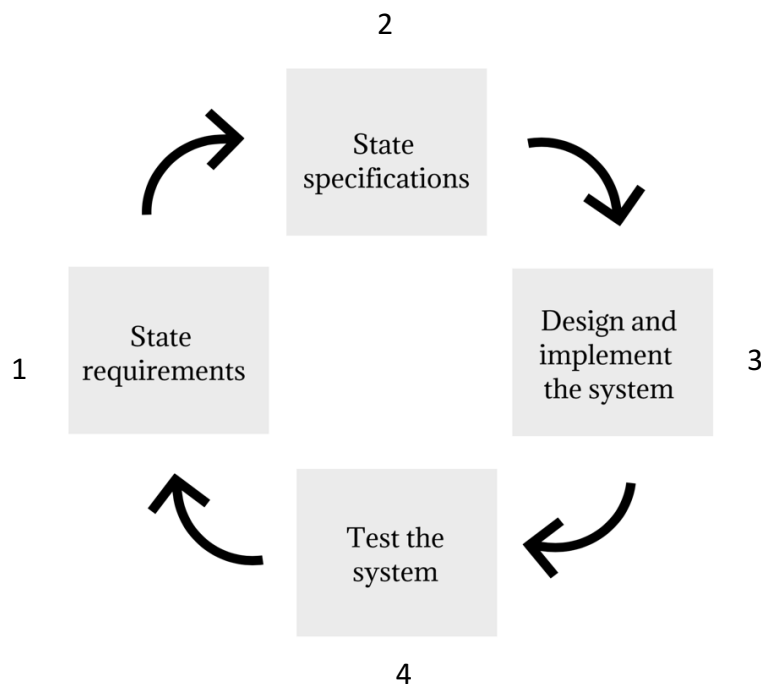

Figure 21. The design paradigm

3.2 Game Design Document

A game design document was created and edited throughout the process in order to organize and keep track of the development proceedings. The game design document was identified as an important factor in the process of developing games (Aleem *et al*.), and was therefore considered an important part of the methods used in this thesis where one easily can follow the game logic.
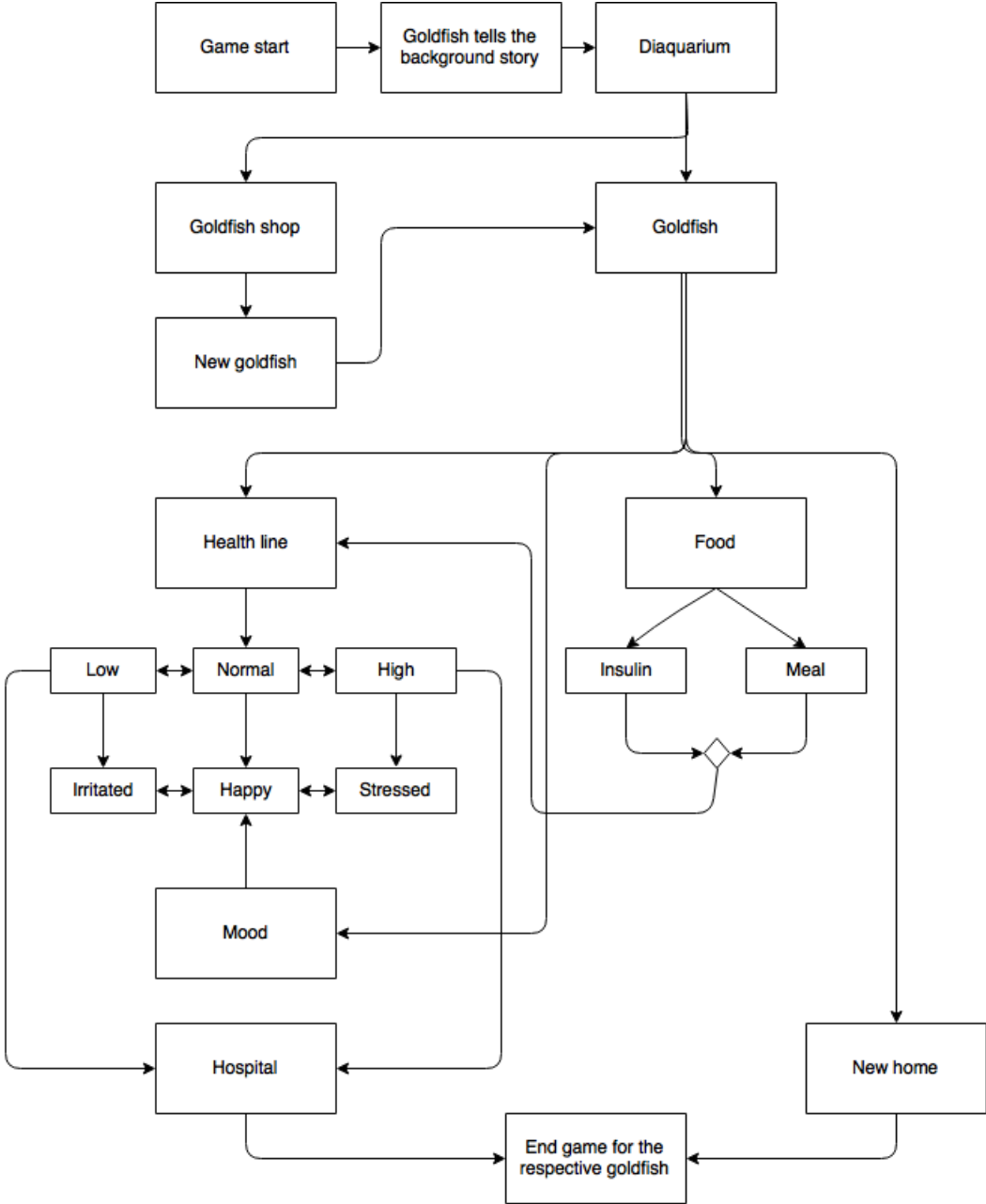

Figure 22. Game Design Document for Diaquarium

3.3 Materials

3.3.1 Game Engine Development Platform

The game engine Unity 3D (Unity, 2016) (version 5.4.3f1 Personal) was chosen as the development platform for this project, enabling the developer to focus solely on the game logic and experimentation. In addition, Unity technologies provides their own full-features built-in editor, called MonoDevelop, that was used developing the project throughout.

Despite that the name of the engine contains "3D", Unity supports 2D developing as well. Embracing 2D animations for this project felt like a natural choice, as I wanted to use my own drawings and illustrations in the game design. As a result, I was able to develop the game as close to my vision as possible.

The Unity 3D engine is a powerful tool that offers different technologies for creating games and apps. Figure 23 illustrates an empty unity interface for a 2D project, but Unity supports change between 2D mode and 3D mode within the existing project. The main difference between these two modes are how assets are imported and how the default camera is set up.

Developers are able to run their games within the Unity Platform, without having to perform any kind of export or built. This makes game development very efficient, as the developer is able to test changes immediately.

Everything inside a game scene is called GameObjects, and developers are able to add functionality to those respective GameObjects by adding Components to them. There are allot of different Components supported by Unity, like MeshRender Components, SpriteRender Components, Components for audio and camera, physic-related Components such as colliders and rigidbodies, and more. To add code to an object, a script Component is assigned to that GameObject.
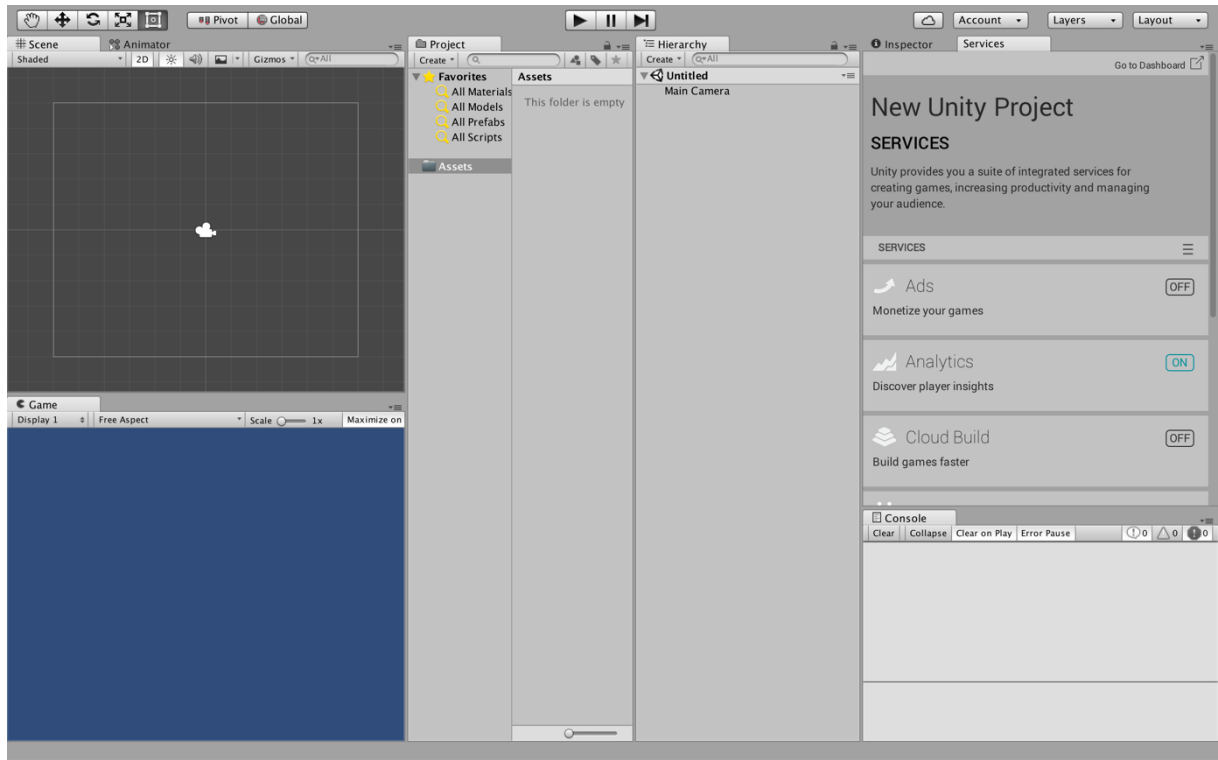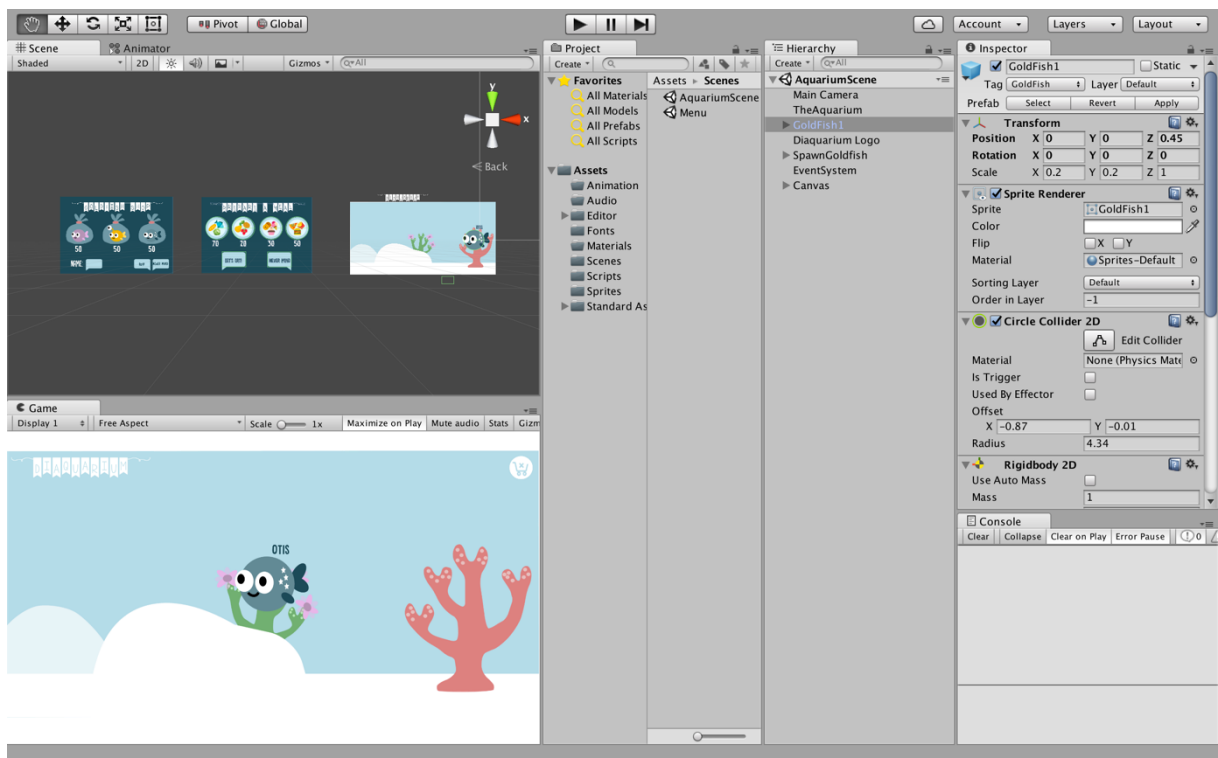
Figure 23. New empty 2D project in Unity

Figure 24. The Diaquarium in Unity

3.3.2 C# Programming language

This thesis uses the C# programming language for its scripting, where C# is one of the languages that interacts with the unity engine.

3.4 Data Collection and Experiment Methods

3.4.1 Literature Review

In order to develop the Diaquarium from a late night idea to a quality game with applied characteristic reinforcement mechanisms, it was essential to do a review of the literature addressed in Chapter 2 and correlate the analysis to the game design.

The findings can be summed as significant gameplay features of the game, and can be addressed as the following.

The user of the application should learn some knowledge about Diabetes Mellitus that can increase their self-management skills. Thus, the game scenario should provide different actions in a diabetes related manner that could possibly result in a learning behavior for whoever playing. In order to do so, correct actions are followed by rewards, but not necessarily right away. Therefore, the game environment should support different actions for users to explore and learn what leads to most rewards. Hence, the user must do some planning in the game. Besides, the game should also exist with several different categories of rewards, where the different rewards should exist with various reward schedulers. The game outline must be structured so that there are always possible rewards to collect in near future, and thereby avoid boring areas with no goals within the gameplay.

3.4.2 Feedback from the Diabetes Team

During the process of designing the game, an early prototype was presented for the Diabetes Team at the Norwegian Centre for E-Health Research. The feedback from the present members of the team were used in further development process. All responded that they liked the presented screenshots of the early game prototype, as well as the idea of an aquarium containing goldfishes with Diabetes Mellitus. They also suggested that the different goldfish emotions should be realistic according to the emotions that is related to hyperglycemia or hypoglycemia. In addition, they liked that the food items in the game were realistic, so that the children playing the game could relate and learn in everyday life.

3.4.3 Discussion with Experts in Diabetes and Psychology

Firstly, several discussions with co-supervisor and expert in Diabetes (Eirik Årsand) was considered a valuable resource in the development process of creating a serious game for children with Type 1 Diabetes Mellitus. As well as doing research on the field at the Norwegian Centre for E-Health Research, Årsand is also personally affected by the ailment and could therefore provide personal experience and examples of living with the disease. He addressed the difficulties and subsequent challenges in everyday life, as well as suggesting new features to consider in the Diaquarium.

In addition, discussion with associate professor and psychologist Gerit Pfuhl with research field in cognitive psychology and neuroscience, decision-making, in statistics and biological psychology, as well as researcher in human motivation mechanism, was considered as an influential part of data collection for this thesis. Discussions mainly took place through e-mails, where we discussed rewards in a learning and motivational perspective. Pfuhl was the one who introduced me to the reinforcement learning theory, a theory that played a big role in the development process of this game. Even though Pfuhls' main research field of

psychology is beyond children matter and do not consider rewards in video games, her expertise has been extremely important when collecting data for this thesis.

3.4.4 Consulting with Children School Teacher and Respective Pupils

In order to get some feedback from potential users, I decided to send a short movie distributed online of an early prototype in addition to an online questionnaire about in-game objects and usability test investigation to a teacher in a children school in Nordland county. She was able to conduct the sent materials to her pupils, who were nine 9-year-old children and thus within the target-group for this thesis. Feedback from the teacher and her pupils affected the game design.

3.4.5 Attending Workshops

The first workshop I attended was the FullFlow Workshop arranged by Diabetes Team in Lyngen. They presented challenges having Type 1 and Type 2 Diabetes Mellitus, as well as an overview of the technologies the Diabetes Team have today and future opportunities. A direct patient feedback from patients and their need in meeting with clinicians and disease challenges also occurred. This workshop found place approximately one month into my own project, and enlightened me of important elements to consider while writing my thesis.

The second workshop I attended was the 2nd International Tromsø/Chicago & ADMIT workshop in Motivational Mechanisms in eHealth. The main goal of the workshop was to gain new insight into the field of motivation and motivational mechanisms in eHealth. The participants discussed how to motivate people to improve their health using different principles, methods, and technologies.

3.4.6 Input from Professor in Persuasive Game Design

Discussion and input retrieved from Professor Visch[1] were conducted in this project, where Vischs' main research area involves persuasive game design. The main topics were distinct effect of monetary, points and social reward types in serious gameplay, in addition to how reward affect gameplay. He later dispatched some of his work, which was of big interest and inspiration during thesis process.

3.5 Evaluation Methods

A questionnaire of an early prototype of the game took place to get feedback from a potential user-group to collect their opinion, wishes and suggestions for improvements, which could be used for future improvements of the application and future projects. It was also necessary to determine if the application was attractive and suitable for the targeted user-group.

Analysis regarding answers from the questionnaire was accomplished by a qualitative method.

3.6 Critique of the Methods Used

The first remark I want to address is the fact that the online questionnaire, (Appendix A) used to collect feedback regarding the game, should have been made earlier in the semester and distributed through several iterations. Then, I would have had the opportunity to distribute the questionnaire to a larger group of appropriate target-users, including users with Diabetes Mellitus.

The second comment is correlated to the questionnaire, where I should have tested it before distributed to the potential user-group. The reason is based on the

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[1] During my attendance at the 2nd International Tromsø/Chicago & ADMIT workshop in Motivational Mechanisms in eHealth, an interesting conversation took place during the unformal dinner with, among others, Valentjin Visch.

partly wrong setup in the questionnaire, where the intended multiple-answers had single answer setup. This could have been detected before it was handed out. Luckily, the teacher and her pupils made a main decision during the test, where they decided to answer what they would prefer the most for the respective questions.

Also, the fact that the potential test-group for this thesis only consisted of nine 9-year old children, as well as the case that there was no actual testing of the game due to an early prototype, the test results should only be interpreted as an indication, and not as objective or convincing.

I also would like to mention that some of the literature used in this thesis was extracted from the work done in my capstone project from fall 2015/spring 2016. Since serious games is a hot topic, new relevant games and new relevant research have most likely been published during this thesis.

3.7 Summary

The following methods were used in this thesis:

- System design
    - o Early prototype, only addressing parts of the main game elements
- Data collection
    - o Literature review
    - o Discussions with experts and colleagues
- Experimentation
    - o Online questionnaire for children
    - o Short movie to illustrate the early porotype
- Evaluation

Chapter 4

Requirements Specification

4.1 Source of Requirements

In order to design and implement an application, the system requirements must be addressed (as step 1 & 2 in the design paradigm for engineers). However, the game development process differs in some ways from the original software development engineering approach. For software engineering, software requirements specification involves a dialogue between software designers/developers and various stakeholders, such as client, users, etc. (Sweedyk, 2009). According to Sweedyk (2009), the process is different for games, where he states that:

"Game design and development incorporates game design in addition to software design and development." (Sweedyk, 2009).

Further, Sweedyk (2009) proposes two steps in the requirement process in game development:

1. Game designers determine requirements from stakeholders. The result is applied in a Game Design Document, along with game design and background research.
2. Software engineers collaborates with the game designers, and converts the Game Design Document into a software requirements specification.

This procedure is followed as far as practicable, with the role of game designer and software engineer merged together. The game design document was created and specified in Chapter 3 as part of the method, and is thus used to create software requirements and specifications in current chapter.

4.2 Requirements

In consideration of defining the requirements for this project, a short scenario presents possible complications that can occur if children with Type 1 Diabetes Mellitus plays serious games to enhance their knowledge about their ailment, but the game lack quality in-game mechanisms.

The scenario suggests that children needs quality tools of serious games to help them understand Type 1 Diabetes Mellitus, how it affects their life, and how to manage it, as well as establish positive association to their disease from an early stage in life. It also addresses the important aspect of considering reinforcement techniques in games to possibly increase motivation for enhanced play-acts. If the game is not perceived as interesting and fulfilling by the intended group, the game has no value among these users and can be seen as useless.

"Those who are considering using a "serious game" intervention should focus on both the quality (and outcomes) of the content they teach and the "game" aspects of the application" (Lewis, 2007)

The requirements in this section has been specified with inspiration to the Volerer requirements specification template (Robertson & Robertson, 2006).

4.2.1 Scenario

Anna has just turned 9 years old, and have recently been diagnosed with Type 1 Diabetes Mellitus. Her knowledge regarding the disease is limited, and she is fully depended on her parents for management of the ailment. Anna doesn't know anyone with the disease nearby, and she often feels alone and helpless when friends at school ask her about Diabetes. She doesn't know what to answer them. Anna remember her doctors talking about Diabetes the last time she was at the control session, but she can't remember what they said. She knows she has to measure her blood glucose levels by sting her finger, but she has no idea what the numbers from the measurement indicates. Also, she doesn't know what to do if her blood glucose levels get too high or too low. Anna has noticed that her nourishment

has changed, but she doesn't know what to eat, or why she requires specific food items at certain times. Anna often feels confused and powerless, because she heard the doctors say that the disease can be life-threatening, and she doesn't know how to handle it.

One day, Anna's mother asks her if she wants to play a video game regarding Diabetes Mellitus to enhance her knowledge regarding self-managing skills. Anna is eager to try as she wants to learn more about the disease, and starts to play the game with a great portion of positive feelings. She soon realizes that her knowledgebase is too low regarding Diabetes, and fails all tasks within. She feels helpless, and the game soon becomes discouraging to her. The game has no quality in-game rewards to indicate whether the actions or decisions Anna made during gameplay were correct or not. Also, there are no encouraging game elements that pushes Anna to proceed more attempts when she fails, and she therefore quits the game. She tells her mother that the game was boring, and that she doesn't want to play it anymore. Anna's mother provides several more serious games regarding Diabetes to her daughter, all with the same result where Anna finds them difficult and boring.

Anna's mother feels worried. She knows there are no meetings or groups in near future that can teach Anna the knowledge she needs, and she had agreed with the doctors to make Anna play the games to enhance her knowledge. In addition, Anna's mother and father experience difficulties providing the knowledge Anna needs, as they don't know how to teach, leaving Anna in frustration as she doesn't know what her parents try to inform.

4.2.2 Functional Requirements

This section includes the requirements that specifies all the fundamental actions of the game, derived from the Game Design Document from Chapter 3.

ID: FR1
Title: Enter the application

Description: When the application icon is pushed, the user gets access to the game content

Reason: Start gameplay

Dependence: None

ID: FR2

Title: Iterate background story

Description: The user clicks on next-button in respect to the goldfish' speech bubble to iterate the background story

Reason: Put users in correct mindset and transport users to next part of the game

Dependence: FR1

ID: FR3

Title: Navigate to the Diaquarium

Description: Users click on yes-button when asked to help, and the Diaquarium is displayed through a new game scene

Reason: Continue gameplay

Dependence: FR2

ID: FR4

Title: Goldfish shop

Description: Users click on the shop icon in upper right corner, and a new image slides through and settles at the center of the screen, illustrating the shop.

Reason: Provides ability to buy new goldfish

Dependence: FR3

ID: FR5

Title: Goldfish

Description: Users click on a goldfish, and its respective health line and other important features are displayed in a line at the lower part of the screen

Reason: Manage and keep track of game character health

Dependence: FR3

ID: FR6

Title: New goldfish

Description: Users click on a new goldfish within the goldfish shop

Reason: Continue play, increase difficulty

Dependence: FR4, FR5

ID: FR7

Title: Name new goldfish

Description: Users write name of new goldfish in textbox

Reason: Give unique personal names to each goldfish

Dependence: FR6

ID: FR8

Title: Proceed purchase

Description: Users click yes-button when buying a new goldfish to accept the purchase

Reason: Complete purchase and transport new goldfish to the Diaquarium

Dependence: FR6, FR7

ID: FR9

Title: Cancel purchase

Description: Users click never mind-button when users change their mind in respect to purchase of new goldfish

Reason: Don't carry out purchase when users change their mind in respect to purchase of new goldfish

Dependence: FR6

ID: FR10

Title: Health line

Description: Illustrates current blood glucose levels for respective goldfish

Reason: Users must be able to keep track of the health in order to master the tasks within the game

Dependence: FR5, FR12, FR13

ID: FR11

Title: Food

Description: Users click on feed me-button to the respective goldfish and a new image slides through and settles at the center of the screen, illustrating a meal menu

Reason: Feed the goldfish to continue gameplay and enhance learning

Dependence: F5

ID: FR12

Title: Insulin

Description: Users shall slide an insulin component to adjust insulin dosage

Reason: Keep the goldfish healthy and enhance learning

Dependence: FR11

ID: FR13

Title: Meal

Description: Users shall drag-and-drop different types of food on a plate to create a meal

Reason: Keep the goldfish healthy and enhance learning

Dependence: FR11

ID: FR14

Title: Low blood glucose level

Description: The arrow in health line is moved to some degree within yellow zone

Reason: Illustrates low blood glucose level in health line, exemplifies that the respective goldfish is sick and users shall provide action

Dependence: FR10, FR11, FR20

ID: FR15

Title: Normal blood glucose level

Description: The arrow in health line is moved to some degree within green zone

Reason: Illustrates normal blood glucose level in health line, illustrates that the goldfish is healthy and does not need any action from user in current state

Dependence: FR10, FR11, FR18

ID: FR16

Title: High blood glucose level

Description: The arrow in health line is moved to some degree within red zone

Reason: Illustrates high blood glucose level in health line, exemplifies that the respective goldfish is sick and users shall provide action

Dependence: FR10, FR11, FR20

ID: FR17

Title: Irritated mood

Description: Change goldfish sprite

Reason: Goldfish has too low blood glucose level, shows that action is needed

Dependence: FR14, FR11

ID: FR18

Title: Happy mood

Description Change goldfish sprite

Reason: Goldfish has normal blood glucose level, shows that no action is needed

Dependence: FR15, FR11

ID: FR19

Title: Stressed mood

Description: Change goldfish sprite

Reason: Goldfish has too high blood glucose level, shows that action is needed

Dependence: FR16, FR11

ID: FR20

Title: Hospital

Description: Remove goldfish from game scene

Reason: Goldfish had too high or too low blood glucose level for too long, e.g., not taken care of, and is therefore removed from the Diaquarium

Dependence: FR14, FR16

ID: FR21

Title: New Home

Description: Remove goldfish from game scene

Reason: The player took care of the goldfish successfully, and is therefore removed from the Diaquarium

Dependence: FR5, FR15, FR18

ID: FR22

Title: Rewards

Description: Reinforce behavior with rewards

Reason: Reward when players perform correct action and decisions

Dependence: FR5, FR10, FR11, FR12, FR13, FR15, FR18, FR21

ID: FR23

Title: Provide knowledge

Description: Educate players with Diabetes Mellitus related knowledge

Reason: Increase users' self-treatment skills

Dependence: FR5, FR11, FR12, FR13, FR14, FR15, FR16, FR17, FR18, FR19, FR20, FR22

4.2.3 Non-Functional Requirements

The requirements in this section specifies the software system attributes.

ID: NFR1

Title: Appearance

Description: Include graphics and animations for actions and reward as part of the design

Reason: User interface shall appear interesting and appealing for the intended user group

Dependence: NFR2

ID: NFR2

Title: Usability

Description: The project shall provide high degree of usability in the user interface

Reason: Satisfy all the needs and requirements of the users

Dependence: None

ID: NFR3

Title: Platform

Description: The game shall be launched on a web-based platform

Reason: Make the game available for all devices without constraints in operating systems

Dependence: None

4.3 Summary

This chapter uses the Volere requirements specification template to describe the requirements for this project (Robertson & Robertson, 2006). A scenario was composed to identify required behaviors, and as a result, 23 functional requirements and 3 non-functional requirements were listed. These are requirements that shall be met by the application.

Chapter 5

Design

5.1 Game Title and Color Scheme

The title Diaquarium was chosen by the author. I wanted to create a main title for the application that was combined by the two key words for this game; "Diabetes" and "Aquarium", hence Diaquarium. I did so to establish a meaning of the title, and, therefore, the title can be seen as part of the design process in this thesis.

In addition, the color scheme of Diaquarium was carefully thought out to be the color blue. At first glance it can be seen as a natural choice due to aquariums and the undersea world are often associated with the color blue. However, the official color of Diabetes is known as the color blue, and therefore the meaning behind choosing blue as the main color scheme was thought as particularly important for this application.

5.2 Designing Platform

All images used in the application, as well as in the design process, was created using the free professional web-based online design platform Gravit. It runs directly on the web, which means that the designer can create new projects from anywhere without needing to install any software or apps.

Inside the Gravit application, you can create different folders to organize the designs (see Figure 26). The application also supports sharing designs with others, by either sharing them explicitly with specified users or persons, or by making the design public (see Figure 27). When a design is made public, other users in Gravit can search and explore shared designs from a "Discover" folder.

The structure of Gravit is so that you assemble several shapes, and together they form an image (design). The shapes used to create the design is structured into a hierarchy on the left side, also known as layers (see Figure 28 and Figure 29). These shapes can then be grouped together in order to duplicate shapes (like the eyes for example).

In addition, Gravit offers a function called media, where the designer can, among others, search for free icons to use in their art. In this project, icons of different food types were applied to illustrate the meals in the game scenario.
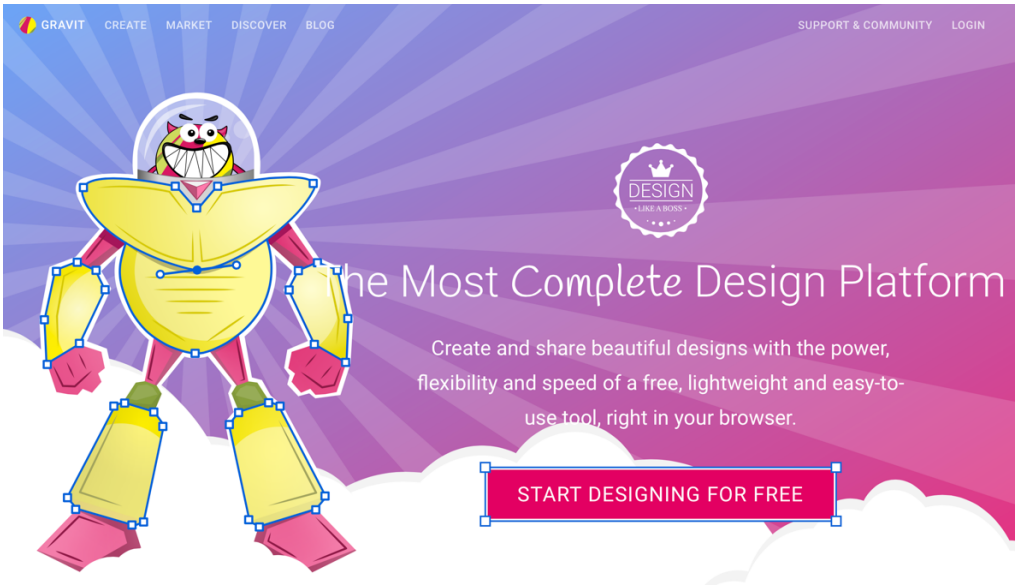
Figure 25. Gravit homepage
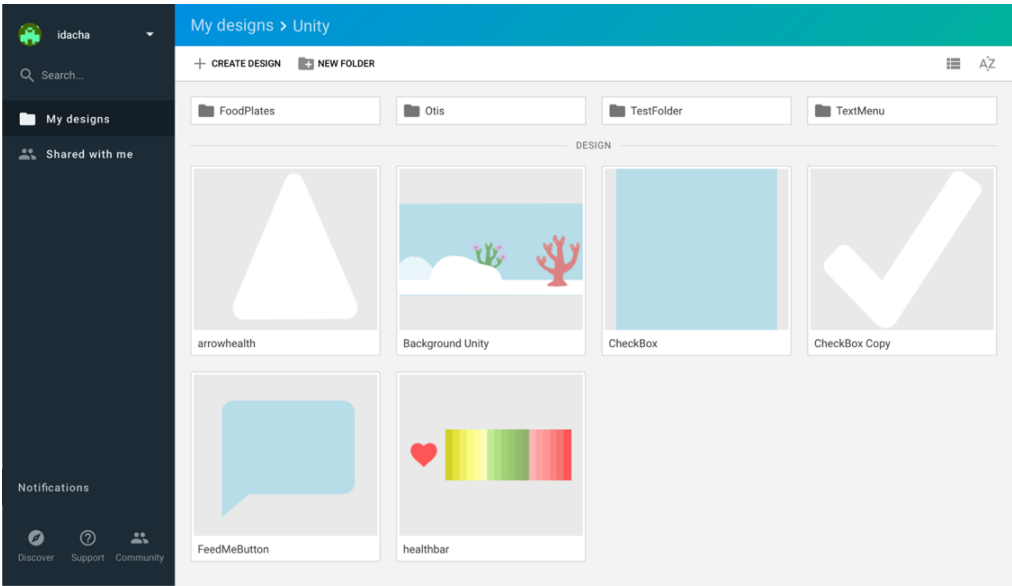
Figure 26. Gravit layout
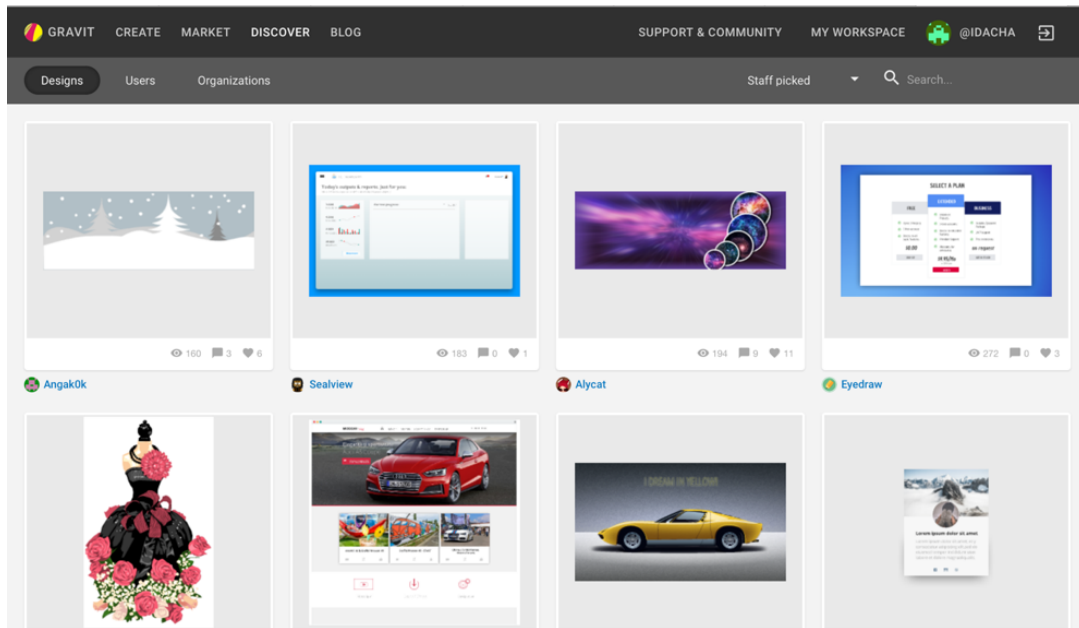
Figure 27. Partial design discovers in Gravit 03.12.16
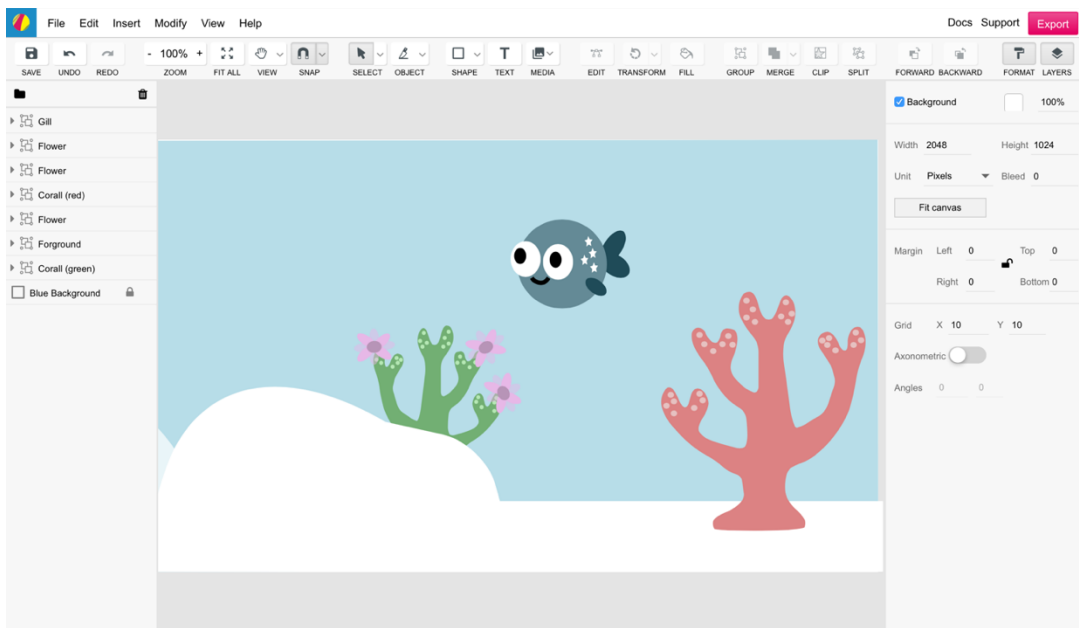
Figure 28. Inside Gravit Designer
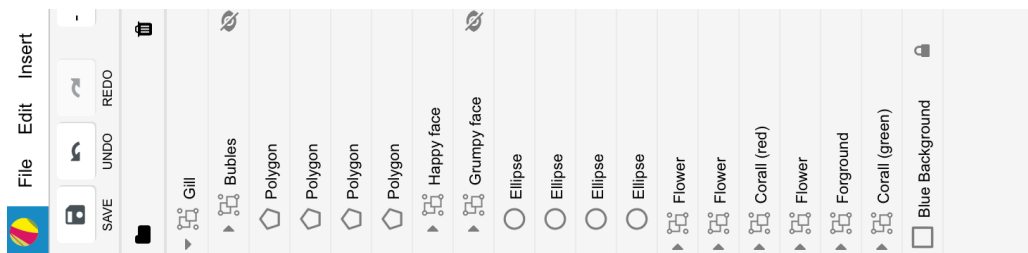
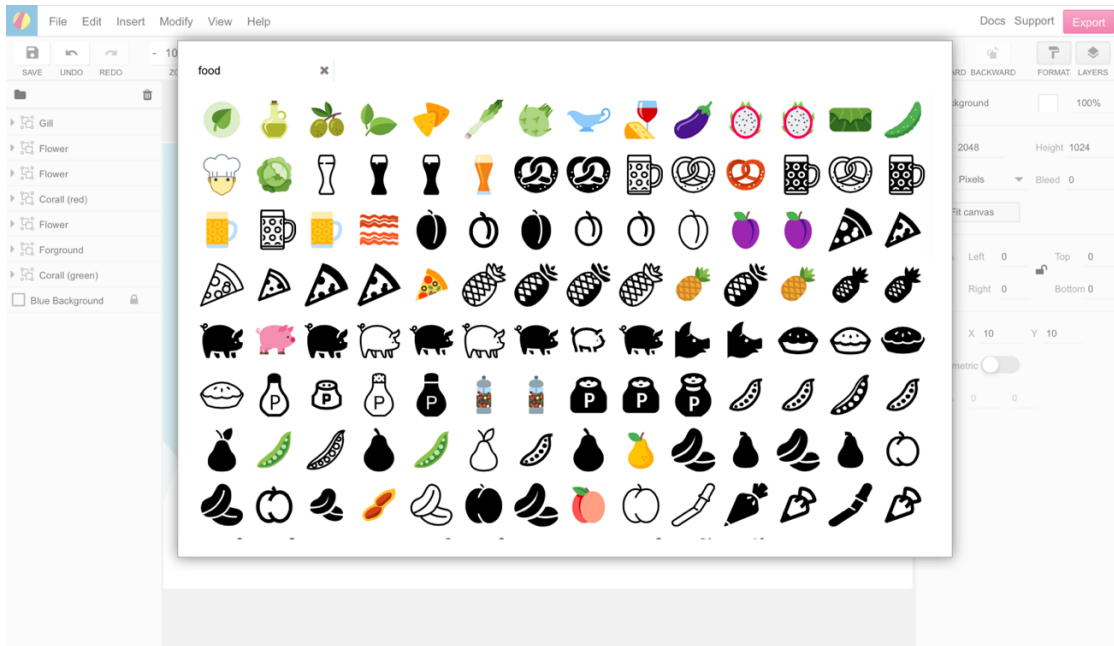*Figure 29. The Gravit folder content for the image from Figure 28*

Figure 30. Section of media icons from search "food" in Gravit

5.3 Identified Game Features as a Basis for Application Design

The game design is a result of several parts of this project, and has been adjusted according to acknowledged theories in the previous chapters concerning background knowledge (Chapter 2) and non-functional requirements identified (Chapter 4), as well as feedback from potential users (Chapter 6).

In addition to the reward perspective when considering game appearance, the game should also provide high usability, which means that the game should be satisfying for the users and the tasks should be easy enough to complete. The game design should also include graphics and animations in order for it to be attractive for children.

As well, learning mechanisms must be thought out in the game design to help children learn some kind of self-managing skills. Some of the different types reward mechanisms must be linked up to the educational content in order for users to feel independence connected to their disease.

Further, the game should exist with an interesting background story, so that the users can connect on an emotional level to the game. The attempt is to create a feeling of being part of something bigger then themselves, being part of something important. By doing so, hopefully, the users will make personal choices for the sake of the good and thereby learn new skills.

5.4 Game Scenario

Both intended versions of the game derive from the same game scenario. It starts with a goldfish named Otis, who presents the story behind Diaquarium. Otis reports that he is diagnosed with Diabetes Mellitus, and that he used to live in a goldfish shop. Unfortunately, the goldfish shop did not provide him the correct food or medicine in order for him to stay healthy. One day, someone from Diaquarium adopts him, and declares that Otis is going to live temporarily in their aquarium until he finds his forever home. In Diaquarium, the goldfishes living there have all Diabetes Mellitus, and those who work in this profession are supplied with correct health care to prevent later health consequences. Now, Diaquarium has allot to do, and they are looking for an assistant that can help them out with the meal and medicine duty. When the player agrees to help, the game is started.

There are no levels in Diaquarium, a design choice made early in the process. The intention was to create a never-ending game (levels would have created an end eventually), so that user input (how active they are (clicks) as well as length in gameplay) could be measured correctly. The idea to measure playtime length was discarded as mentioned, but the concept with no levels remained. Even though there are no levels in the Diaquarium, users have the opportunity to increase the number of goldfishes as they like if they have enough resources to do so, which will eventually raise the difficulty of the game.

When users click on a goldfish in Diaquarium, some main information reveals itself in respect to that specific goldfish, such as name, health status according to a glucose barometer, food-button, and potentially a new-home-button if ready to move into a forever-home. The player must choose combinations of food

and correct amount of insulin according to the glucose status to keep the goldfish healthy and satisfied.

In order for the game to be continuous, players must choose to provide the goldfishes new homes, as well as buying new goldfishes from the goldfish shop.

5.5 Game Content

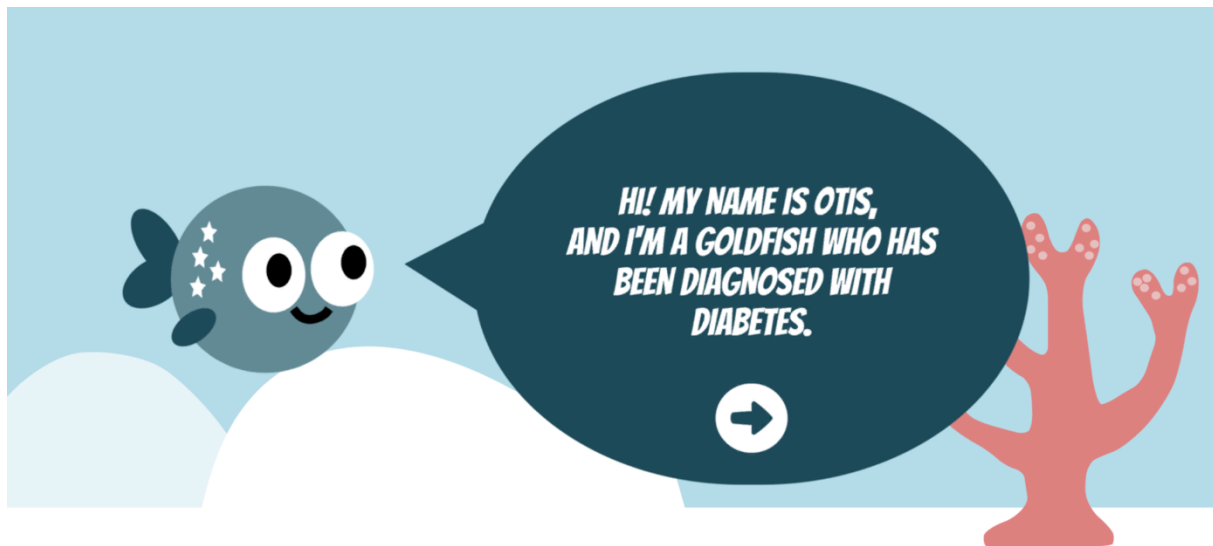The following chapter outlines the content within the game.

5.5.1 Game Start

Figure 31. Game start in the Diaquarium

When the game starts, the head character Otis appears on the screen and reveals the background story too the player through speech bobbles. In order for the user to understand that the game is active, Otis appears with a small swimming animation up and down on the screen. An arrow in the speech bobble signalizes the next step in the game. When clicked, a new speech bobble appears to iterate the background story.

Figure 32. Speech bobble 2 & 3

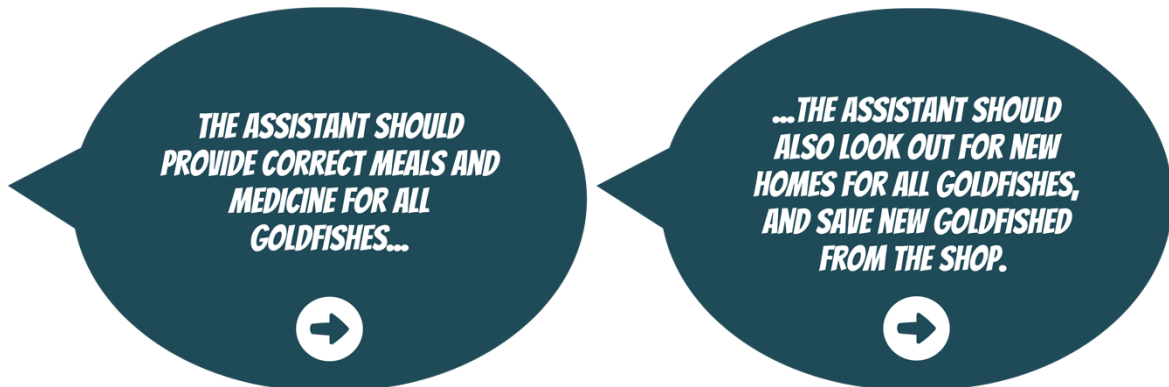

Figure 33. Speech bobble 4 & 5

Figure 34. Speech bobble 6 & 7

Eventually, the user is asked if he/she can help Diaquarium. When clicked yes, the user agrees to assist, and the game outline begins.

Figure 35. Speech bobble 8

5.5.2 Game Outline

After making the user familiar with the background story, the aquarium covers the screen and the user is ready to play the assistant role in Diaquarium. First, Otis demonstrates the main features of how the gameplay is carried out by some small animations and speech bobbles. These features are known as the core mechanisms within the game, also identified as the game outline.
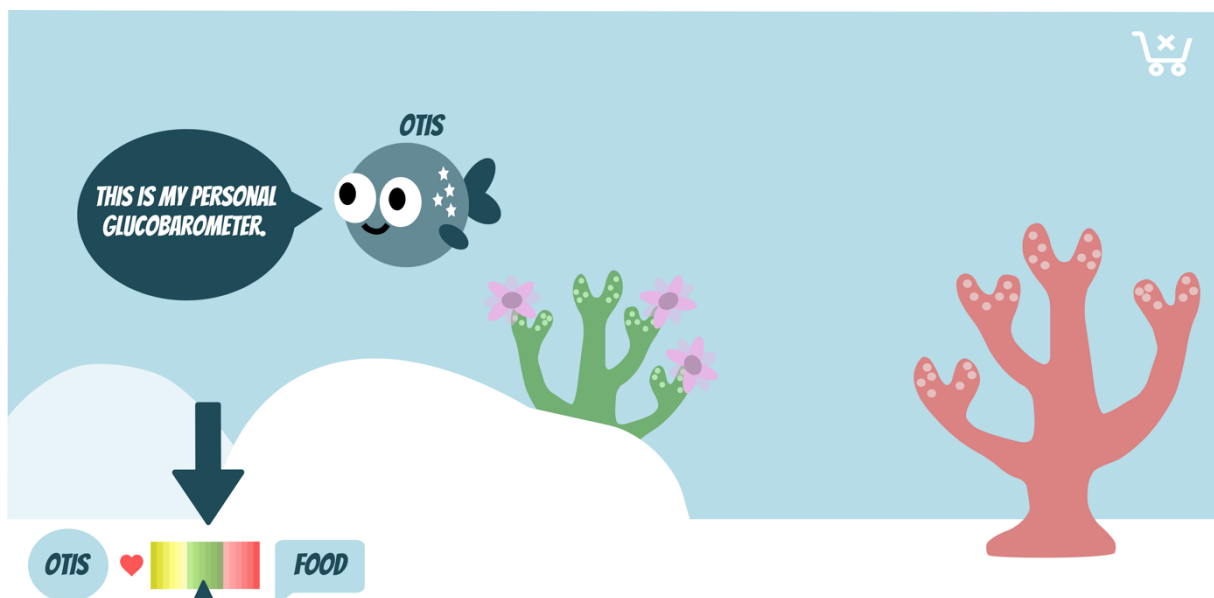

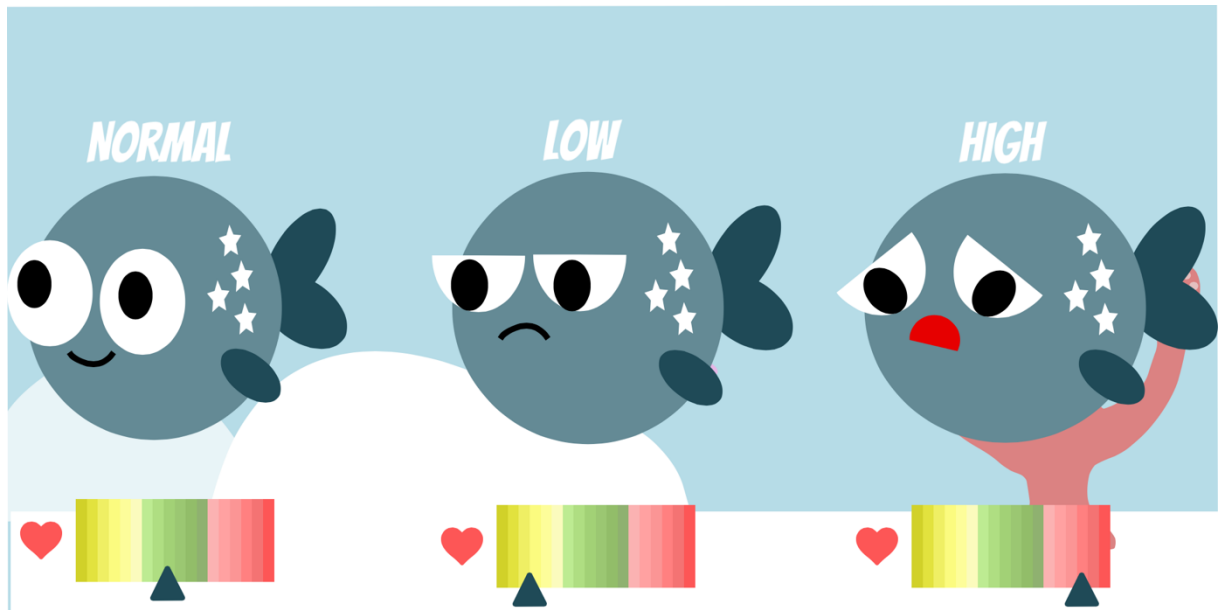*Figure 36. Spotlight: glucose barometer.*

Figure 37. Emotions in relation to glucose level in bloodstream

Otis shows the glucose barometer as an imprint of his current glucose level in bloodstream (health) at any time. If the blood glucose level drops low (yellow zone in the glucose barometer), or too high (red zone in the glucose barometer), the goldfish facial expression changes (see figure 37). In order to keep the blood glucose level normal (green zone), the assistant must provide correct food and insulin dosage.
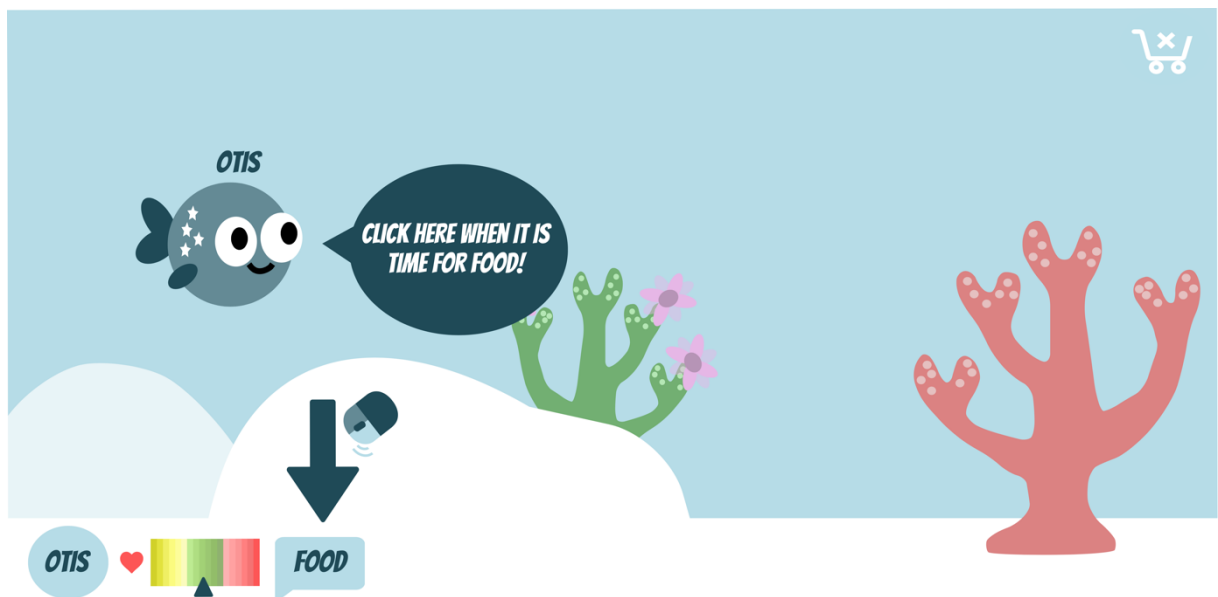

Figure 38. Spotlight: food-button.

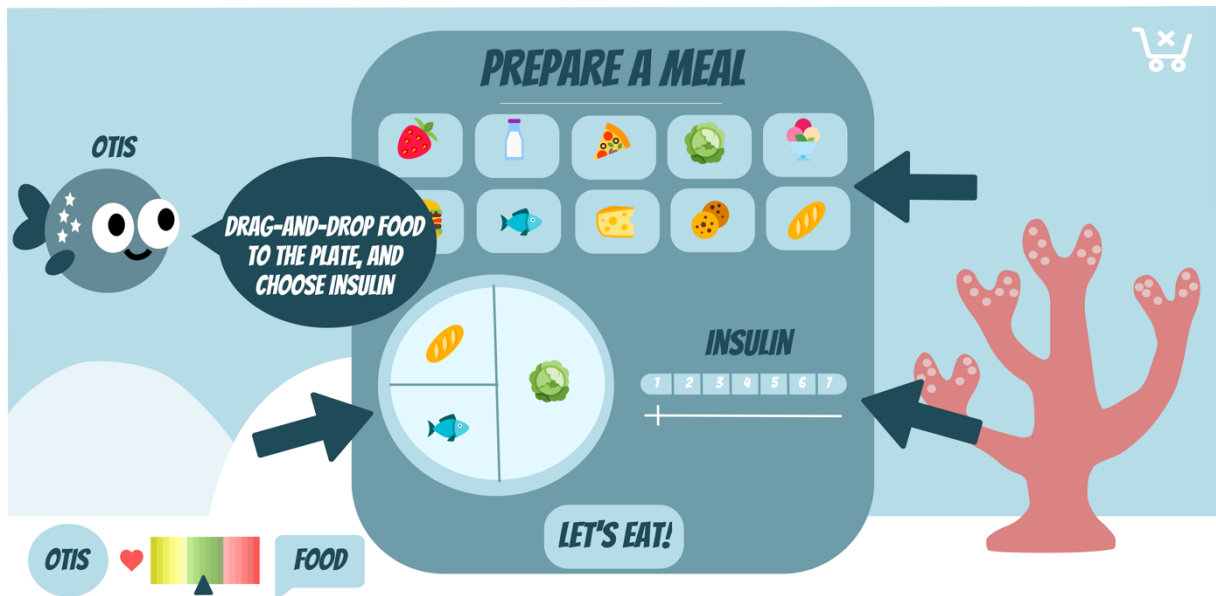Otis shows that the food-button must be clicked in order to provide meals and insulin.

Figure 39. Spotlight: prepare a meal

When the assistant interacts with the food-button, a new window appears sliding in from the left side of the screen. Next, Otis points out how the assistant must drag-and-drop different food-items on the plate and choose insulin dosage in order to complete the task. The amount of insulin affects the blood glucose levels according to the food items chosen.
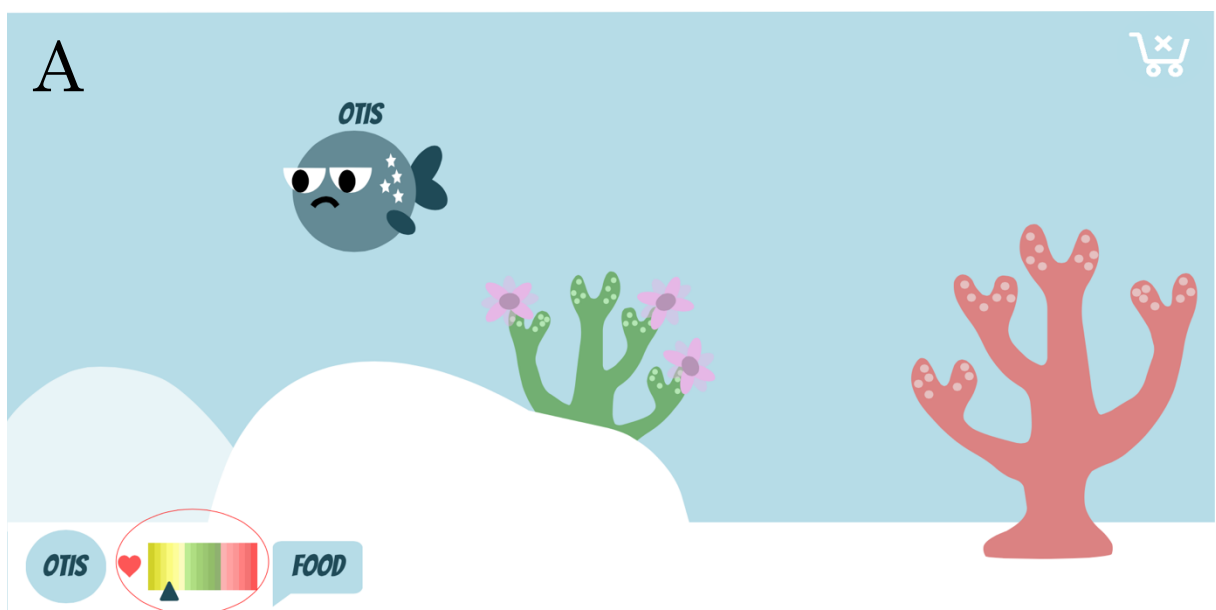
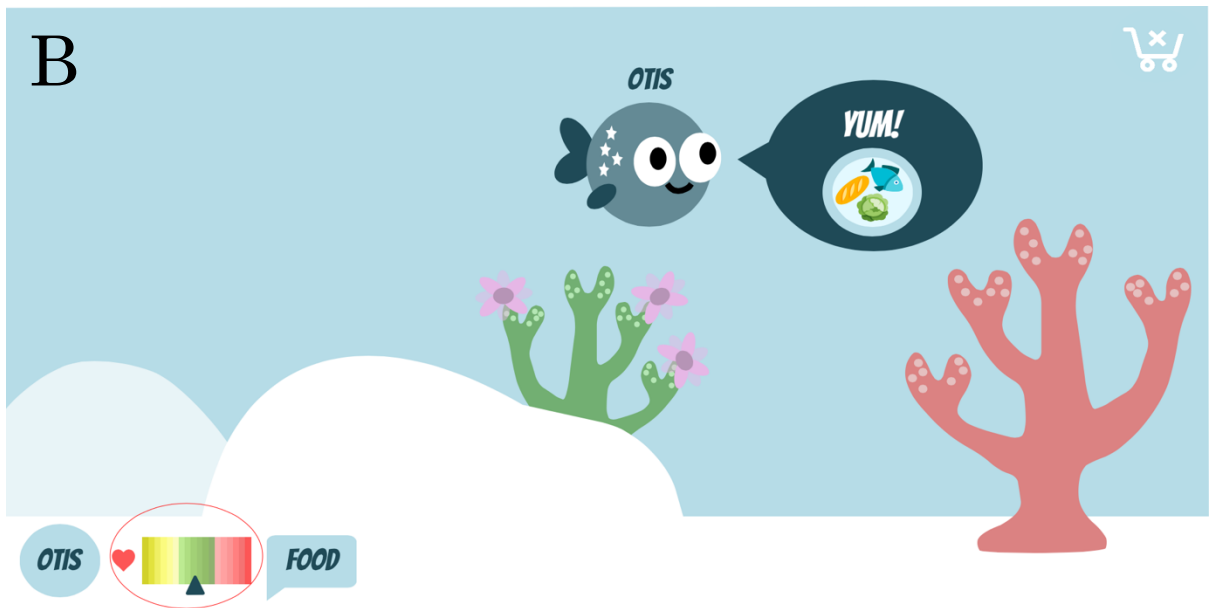*Figure 40. Spotlight: Low blood sugar levels (yellow zone)*

Figure 41. The goldfish receives a plate of food, and the blood sugar levels gets back to normal (green zone) if the meal and insulin dosage were correct for that specific case.
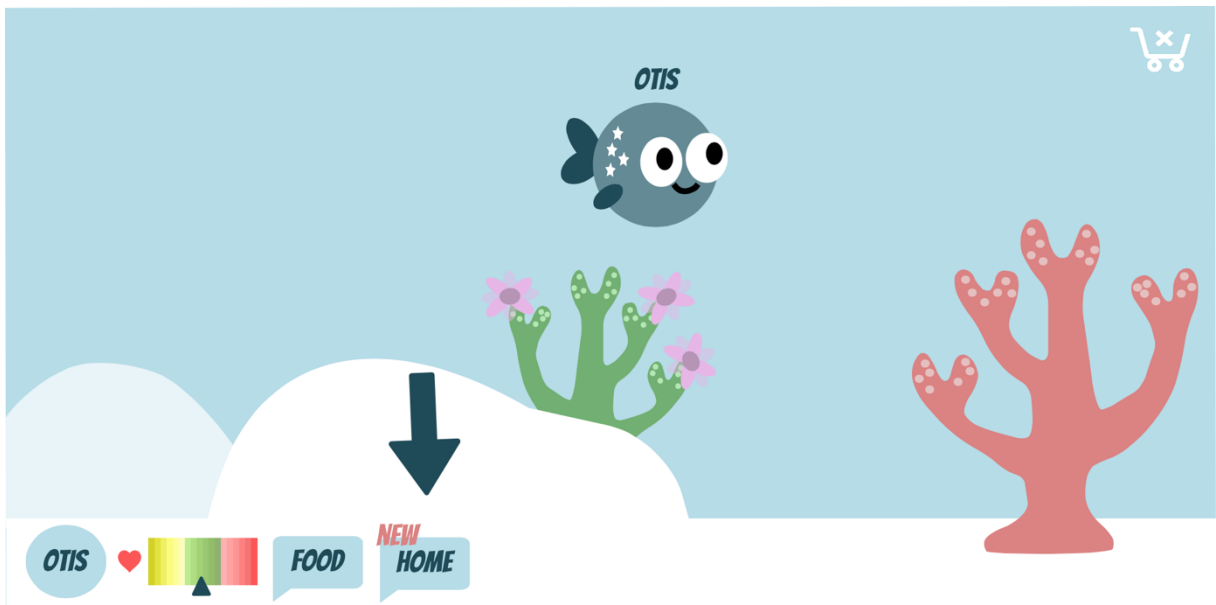

Figure 42. Illustration of new home-button that appears on the screen when a goldfish is ready for his new forever home

Figure 43. The goldfish moves to his new home

When goldfishes move to their new homes, they will naturally be removed from the Diaquarium and does not require any more assistance.

For the sake of a continuous play and increase the difficulty of the game, the goldfish shows the assistant the possibility of visiting the local goldfish and save some more goldfishes (Figure 44). In the store, you can choose between three types of goldfishes and give them their own names (Figure 45).
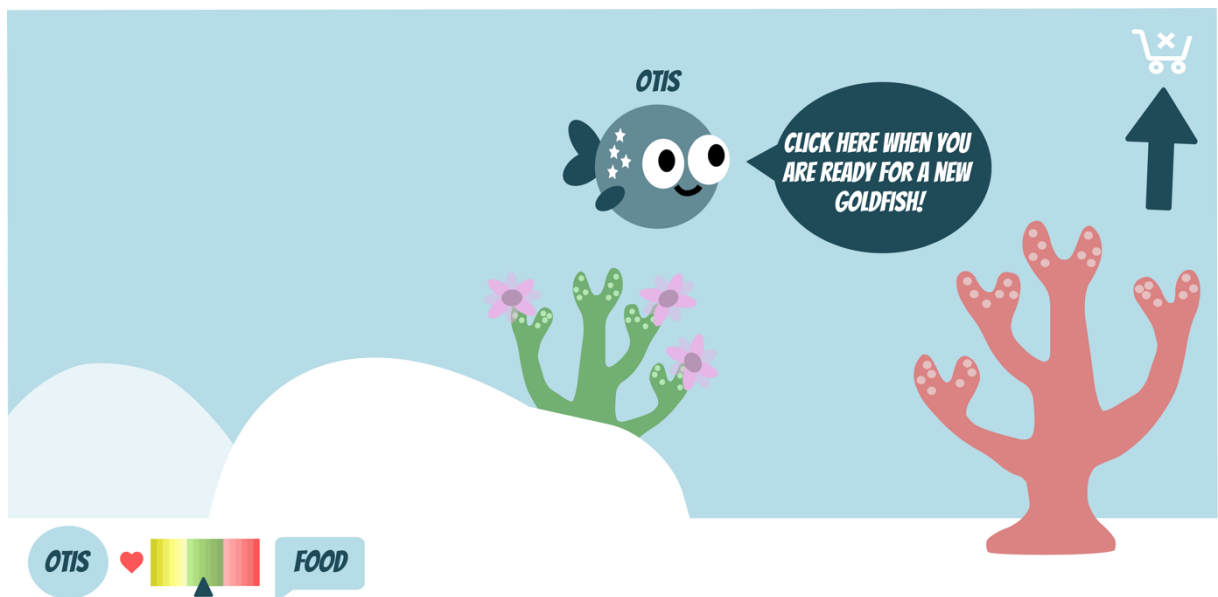

Figure 44. Spotlight: shopping cart

Figure 45. Spotlight: the local goldfish shop

The number of goldfishes in the Diaquarium is completely the choice of whoever playing the game. However, because the Diaquarium is constrained to one frame, the number must not exceed a maximum limit related to the physical space in the Diaquarium.
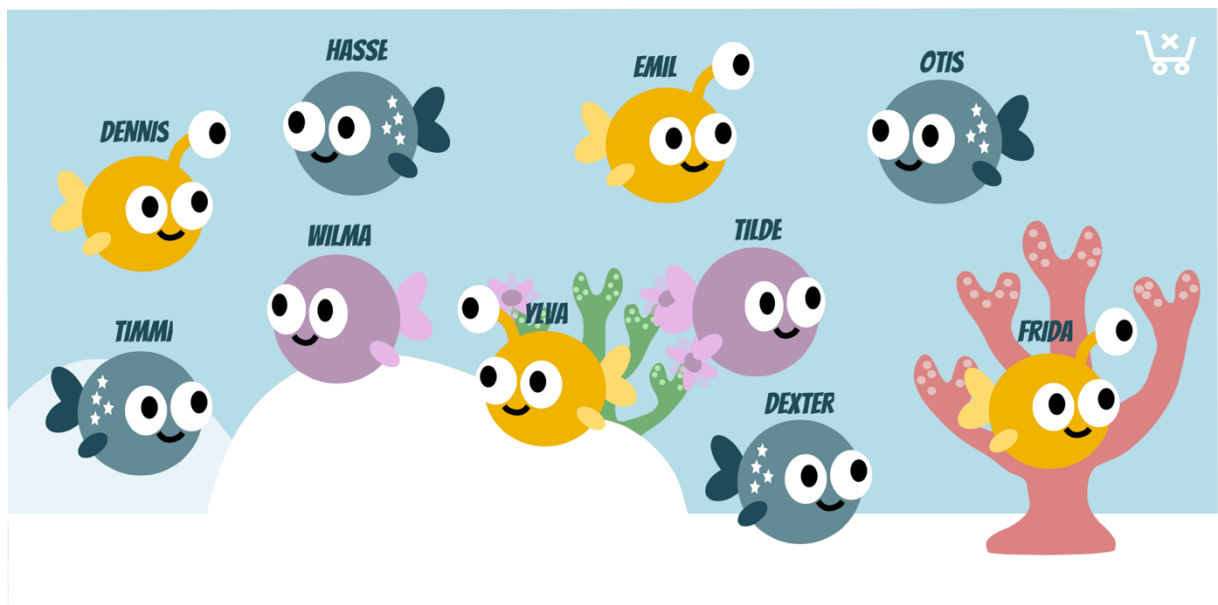

Figure 46. 10 different goldfishes in the Diaquarium

If a goldfish resides too long in either the yellow zone or red zone of the health line, the goldfish must move to the hospital to avoid serious later complications. The player gets noted by an image, and the goldfish is being removed from the Diaquarium immediately. The assistant cannot longer care for that particular goldfish.
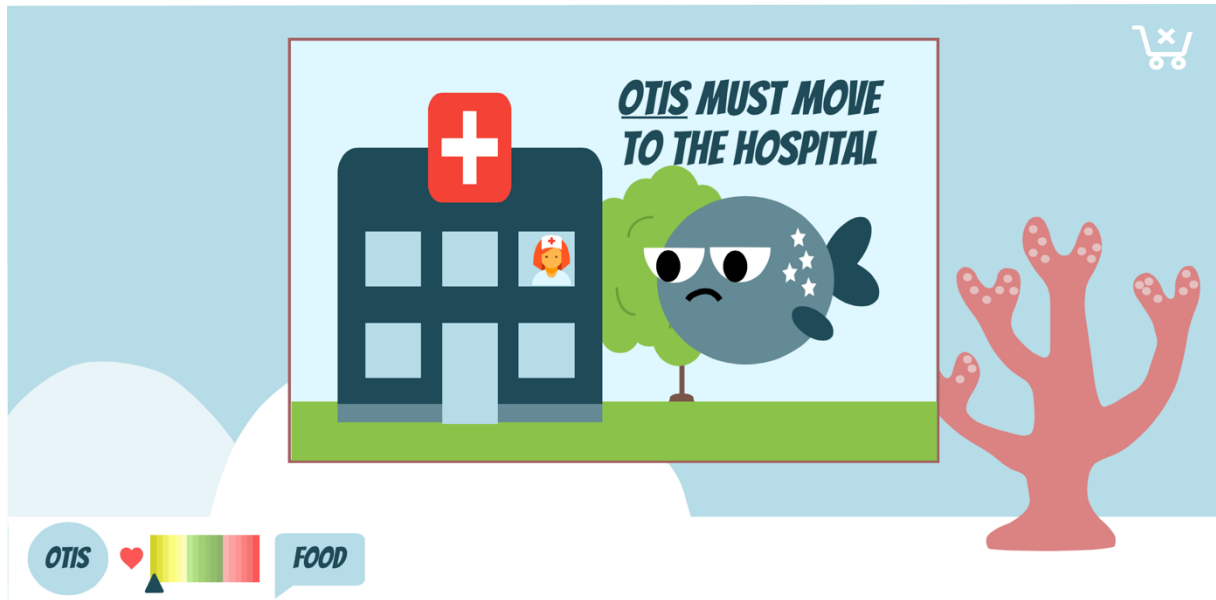

Figure 47. The player gets the message that one of the goldfishes has been moved to the hospital

5.5.3 Rewards Applied in the Diaquarium

5.5.3.1 Positive Rewards

The players receive their first reward when they launching the game. The reward is a surprise, and the player will never know what they get until they have launched the game. The reward can be any of the following:

- Gold coins
- A free goldfish
- A medicine packet that keeps the goldfish within the green zone on the health bar for approximately 1 minutes (e.g., the assistant doesn't need to do anything for that goldfish within this amount of time)

- Slow increase or decrease in blood sugar for 1 minute

Figure 48. Welcome reward

Another reward is praise for checking on a particular goldfish. The player must click on the goldfish to check its health status, and the game randomly makes that particular goldfish talk to the assistant. The goldfish tells the player in different ways how good they are doing with the assistant job, like the example in Figure 49. Other praises could possibly be

- "Amazing! You are doing a really good job!"
- "Wonderful! You are so thoughtful"
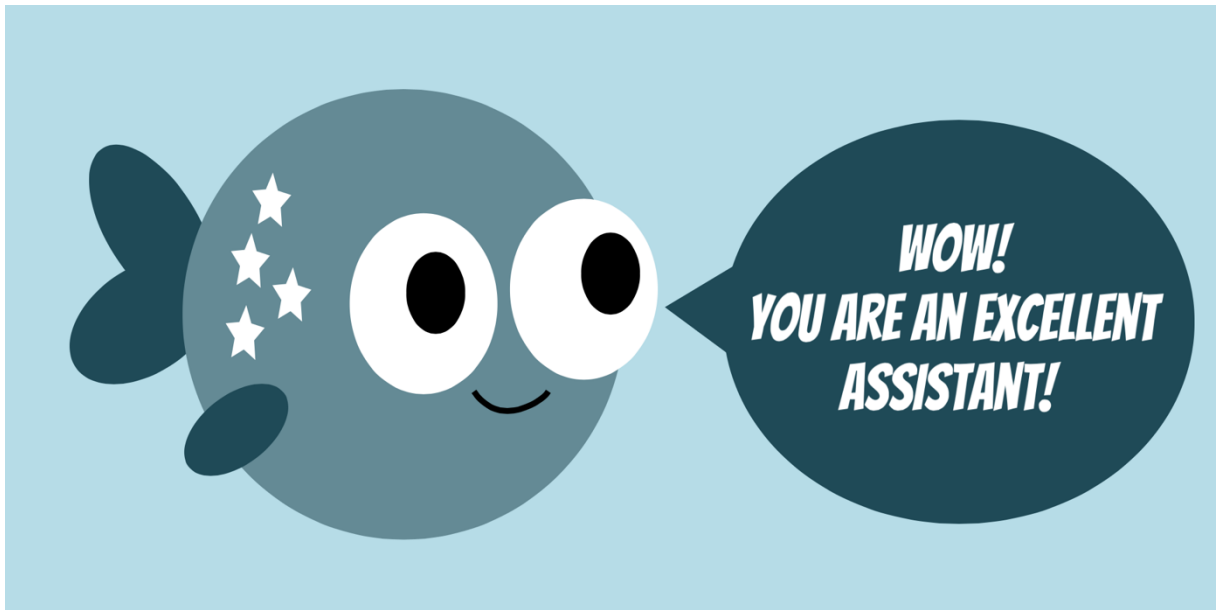- "You take good care of me, thank you!"

Figure 49. Praise for looking after the goldfish

The assistant (player) will be rewarded if they manage to stay within the green zone of the health line for 1 minutes at a time (see Figure 50). Whenever a goldfish enters the green zone within their individual health line, a clock starts counting down 1 minute. Note that each goldfish has their own exclusive clock for each respective health line. If the goldfish moves over to the yellow zone or red zone of their health line, the clock will disappear for that particular goldfish. The clock does not cache timestamps when a goldfish leaves the green zone, and will therefore always start over again when the green zone is entered respectively. Whenever the count-down is completed, the assistant (player) receives 100 gold coins as well as praise for doing a good job. The game is fair, and the clock start immediately a new count-down when 1 minute have been accomplished and the goldfish is still staying inside the green zone.

If the player manages to stay within green-zone for 3 count-downs in a row, the assistant is being rewarded with a medicine packet (see Figure 51). The medicine packet pauses the goldfish within the green-zone for 1 minute, making the player earn free gold coins as the clock continues to tick down.

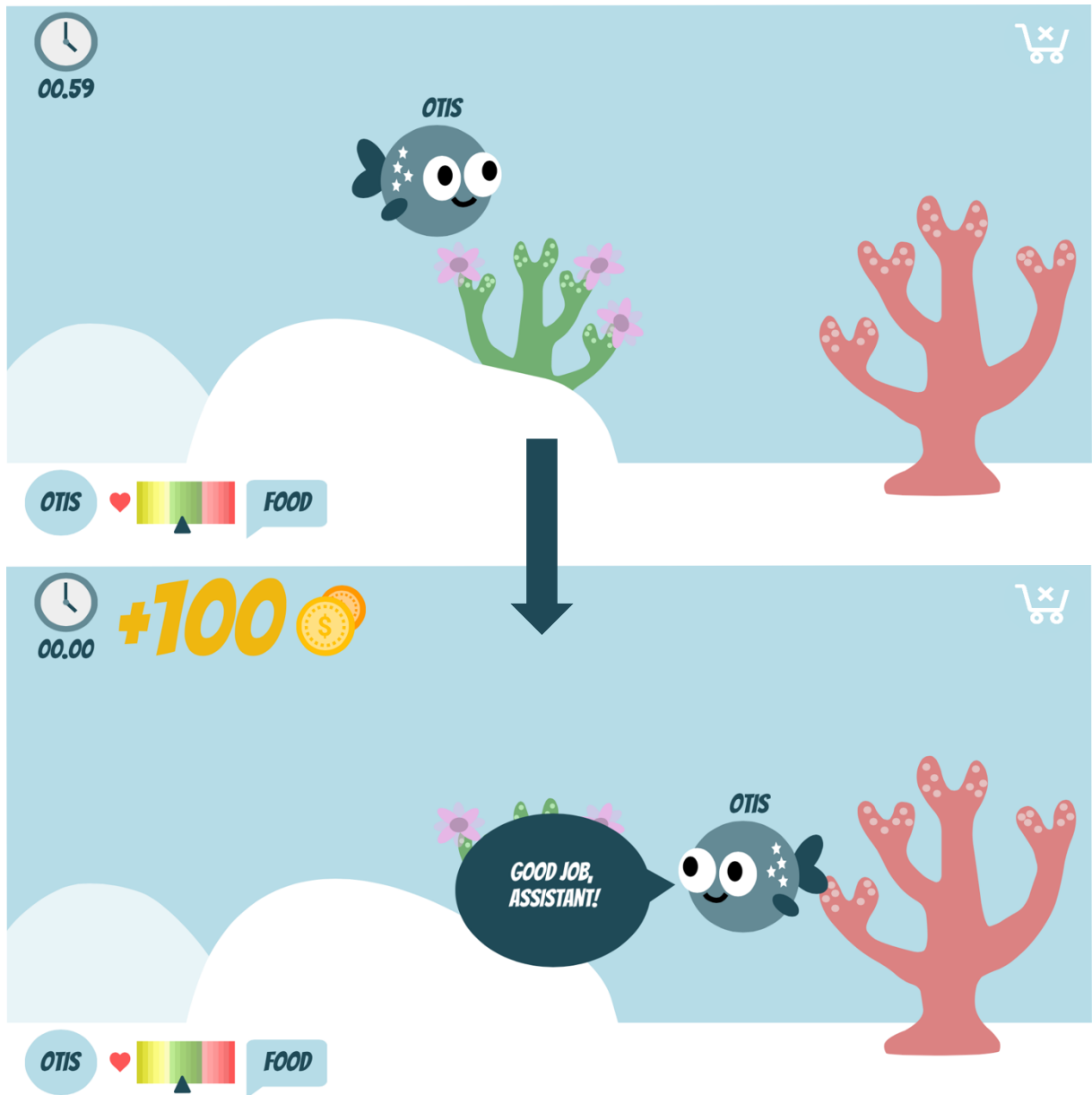*Figure 50. Illustration of reward that is received after 1 minute of staying within the green zone of the health line.*

Figure 51. 1 Minute of medicine packet

If the goldfish receives correct food and insulin dosage, they will express their gratitude with words such as "Yum!", "I like this!", or "You're a good chef!".
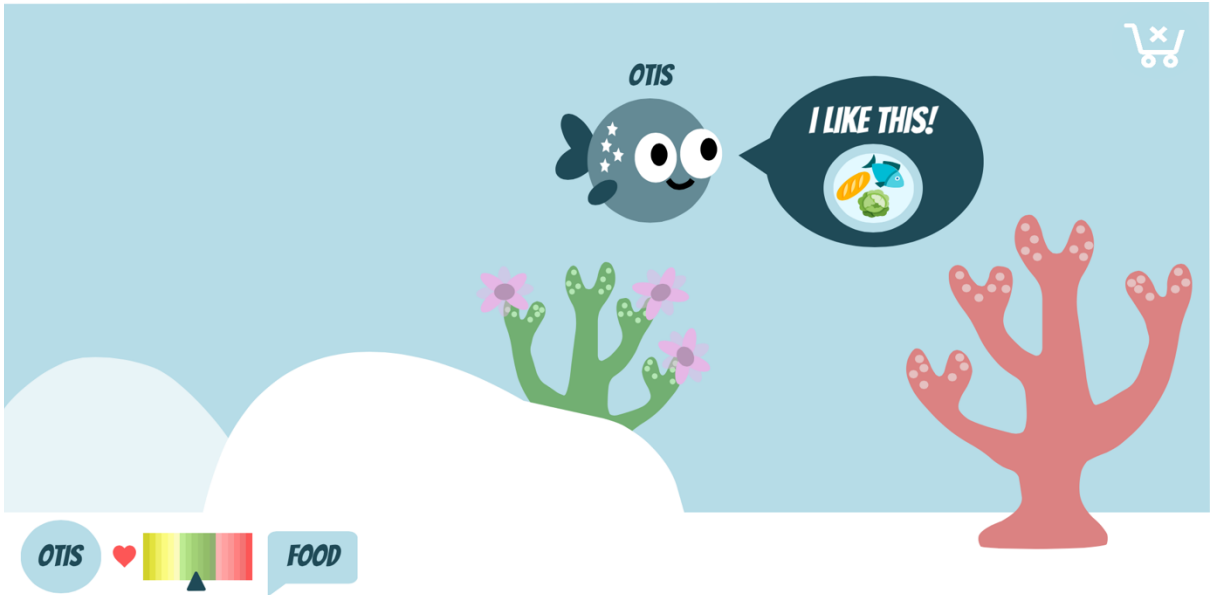

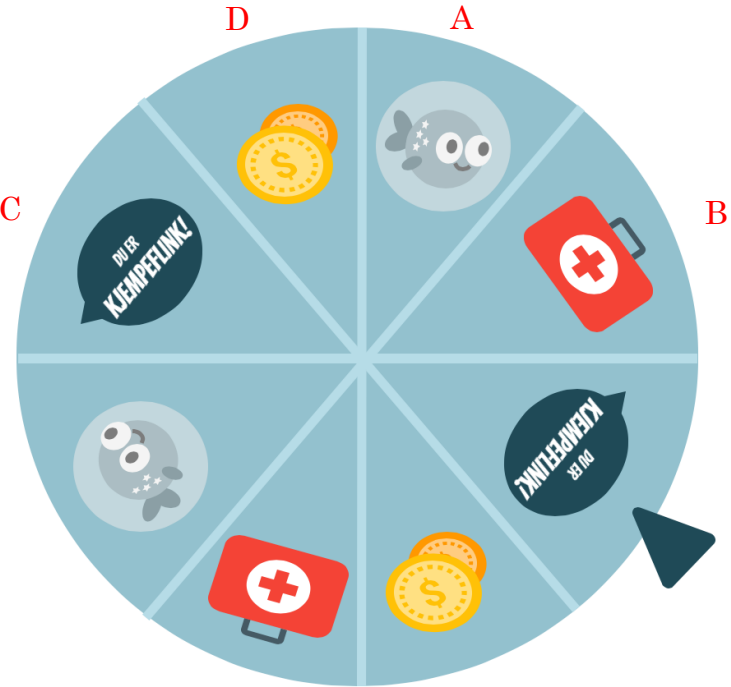*Figure 52. Correct food is rewarded with praise*

Figure 53. Lucky wheel with rewards

If the assistant (player) carries out three correct meals in a row with appropriate insulin dosages, a reward will be earned through a price in the lucky wheel (Figure 53). The lucky wheel contains four types of rewards:

- A) Slow increase or decrease in blood sugar for 1 minute
- B) A medicine packet that keeps the goldfish within the green zone on the health bar for approximately 1 minutes (e.g., the assistant doesn't need to do anything for that goldfish within this amount of time)
- C) Praise
- D) Gold coins

Figure 54. The assistant is getting paid gold coins

When the goldfish is ready to move to his forever home, the assistant (player) gets rewarded with gold coins. However, the there is a little twist with this particular reward – the player never actually knows how much they will get paid until they get it. They can earn 100 gold coins one time, and 50 gold coins the next time as an example.

In addition, the player is rewarded with a new type of goldfish in the goldfish shop for every random number in range of 1 to 5 goldfishes who found their forever home. To exemplify, the player will be rewarded with a new type of goldfish in the

goldfish shop after movement of 3 goldfishes (not necessarily in a row), and next time after the movement of 1 goldfish.

Figure 55. New type of goldfish

5.5.3.2 Negative Reinforcement

The game scenario of the Diaquarium includes some negative reinforcement as well.

If the goldfish experiences long time periods of too low or too high blood glucose levels, extra seconds will be added to the goldfish time in Diaquarium before it finds its forever home. The player must therefore do some kind of planning along with actions to keep the goldfish within normal level of blood sugar levels so they can move to their new home and the player can rescue new goldfishes, and thereby create a prolonged play.

Also, too long time periods of too low or too high blood glucose levels will result in having the goldfish transferred to the hospital, e.g., removed from Diaquarium without the players' consent. Besides, the player must pay for the hospital stay, losing some of the already earned rewards (see figure 56).

Additionally, if players deliver wrong food regarding the situation and/or inappropriate amount of insulin, the goldfish will respond with quotations like "I

don't like this!" or "This was not good for me...." along with adjustments in blood sugar levels (see figure 57).
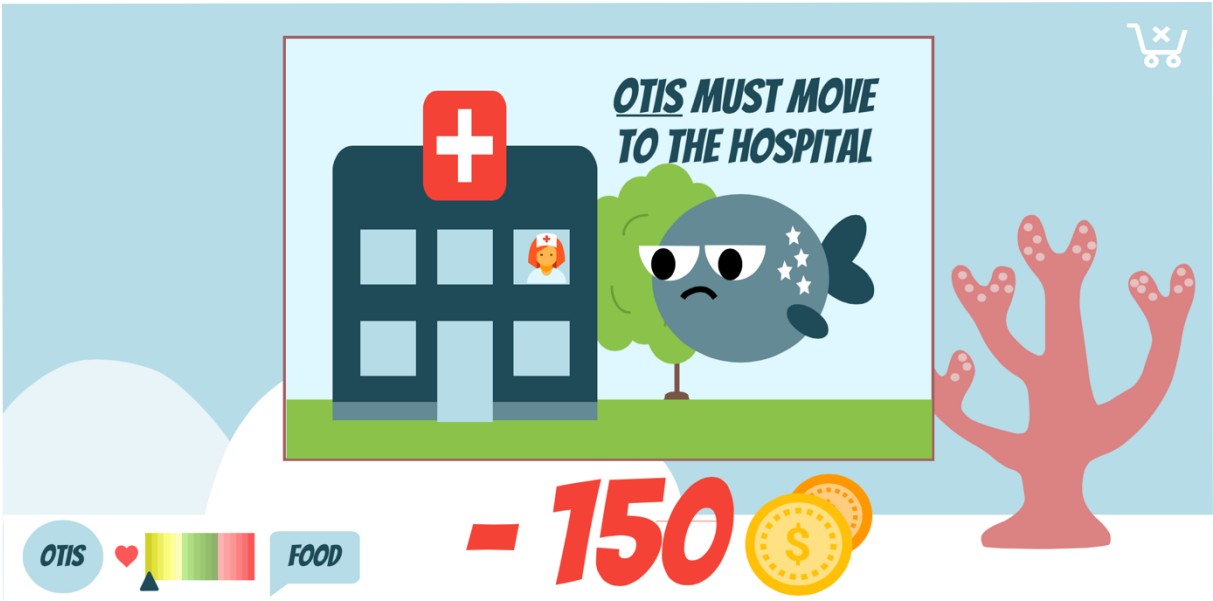
Figure 56. Pay for hospital stay
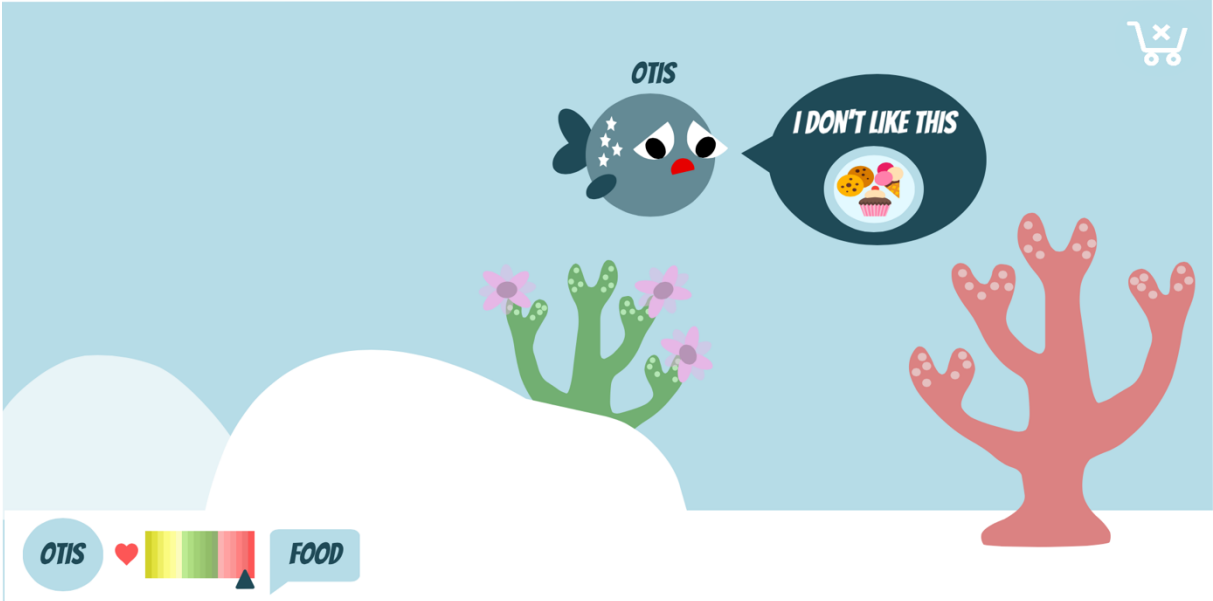
Figure 57. Incorrect food and insulin according to blood sugar level

5.6 Early Version of the Application

Figure 58 and Figure 59 illustrates an early version of the game used as illustration when explaining the idea for supervisors and colleagues. The current design in this thesis is rooted in this early version. The early version contains some differences from the current design, where, among other, the background history was a short story presented in one square on the screen. In addition, health line and other important attributes were displayed in a square attached to the respective goldfish. The only existing game scene was the Diaquarium.

Figure 58. Early version of the Diaquarium (1)

Figure 59. Early version of the Diaquarium (2)

5.7 Summary

The history of the game title and color scheme is mentioned in the beginning of this chapter. Then, it is described how sprites were created for this project, using the design tool provided by Gravit. Next, a brief game scenario is presented. Following, the game content is described in details, including game start, game outline, positive rewards, and negative reinforcement mechanisms. Lastly, this chapter illustrates the early version of the Diaquarium that current game design derives from.

Chapter 6

Test and Results

This chapter addresses the testing procedure and the respective results regarding the game in this thesis. Due to a very early prototype of the Diaquarium not ready to be tested at that time, it was by nature not performed any application tests. Nevertheless, it was necessary to get relevant feedback from potential users for further design and development improvements, and an online questionnaire were distributed to a potential user group.

6.1 Testing Procedure

The test consisted of a short movie distributed online and an online questionnaire that was distributed over e-mail to a teacher in Nordland county. She performed the test on her 9 pupils in a classroom (Figure 60), where they answered the questions on their respective laptops while the teacher read the text. The pupils were considered a qualified test-group for this project as their age were approximately 9 years old. Because of their age and limited writing/reading skills, it was decided to create the questionnaire with multiple-choice answers for the majority of the questions.

The test consisted of four parts. First, a short video of the implemented game was displayed via projector on a big canvas in order to illustrate the core mechanisms and game concept. The test-group was informed that the video was only for demonstration of the game, and not a potential end-result game. Then, the complete game outline in detail was presented through text and illustrations. Consequently, the test-group was able to achieve higher understanding of the game outline in a correct manner, and could thereby provide accurate feedback in relation to the intended game. Next, questions considering reward preferences within the Diaquarium was conducted. Lastly, usability questions concerning the

game were attended. All text was read out loud by the teacher to assure that the children were joined by contents.

The questions in part three were as follows.

1. Are you a boy or a girl?

2. Do you like to play games?

3. Do you like goldfishes?

4. What platform do you like to play on?

5. You are rewarded for providing correct food and medicine to the goldfish. What type of reward do you like best?

6. If you have to choose 1 reward, what reward do you like the best?

7. What rewards do you like the least?

8. Can you mention other rewards in games that you like?

9. When a goldfish moves to his new home, you will be rewarded with gold coins. Would you prefer a fixed price, or try the luck and see how much gold coins you got?

10. You will be rewarded with for example gold coins if you manage to stay within the green zone within life line. When do you want to receive the reward?

11. You will be rewarded if you manage to create 3 correct meals in a row. How to you want to receive the reward?

12. Would you like a free reward when you start the game?

13. You have to pay with gold coins if the goldfish must stay in the hospital. What are your thoughts about that?

14. You can potentially fly to other aquariums and chat with the goldfishes there if you have collected enough rewards (like for example medals). What are your thoughts about that?

The final part consisted of questions as follows.

15. What do you think about the game?

16. Do you want to try the game one day?

17. What do you think of the colors in the game?

18. What do you think about the story takes place in an aquarium?

19. Do you like that the characters are goldfishes?

20. What do you think of the illustrations in the game?

21. Do you think the game looks difficult?

22. Was it difficult to understand what the game was all about?

23. Was it difficult to understand how you could receive rewards in the game?

24. Do you have other suggestions that I can include in the game?

The complete questionnaire can be found in Appendix A.

Figure 60. Test environment

6.2 Test Results

The gender distribution was fairly equal for this particular test-group, where 4 were boys and 5 were girls. When asked if they liked playing games, 88.9 % said they liked it, and 11,1% answered a little. The 11,1% was gendered girl.
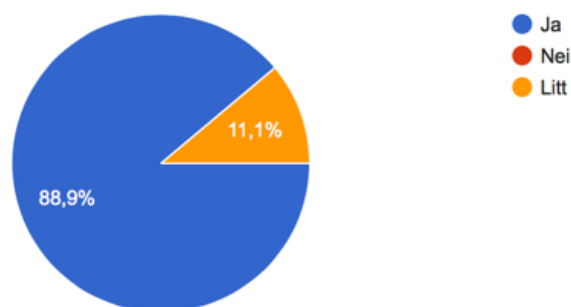
Figure 61. Result for question 2

When asked if they liked goldfishes, 77.8% answered yes, while 22,2 answered little. Also here, the 22.2% answered little was gendered girls.

Liker du å spille spill? (9 svar)
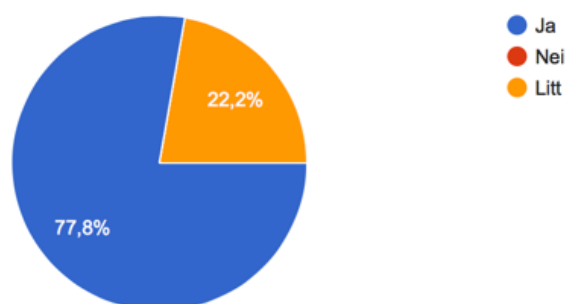
Figure 62. Result for question 3

When asked what device they mostly played on, the intention was multiple-choice answers. However, something was incorrect with the questionnaire layout, and the children were only able to choose one answer. In consolation with the teacher, they answered the device that they used to play on the most. The result shows that iPad is the device that most of the children in this test-group uses for gameplay on a regular basis.

Hva pleier du å spille på? (Du kan krysse av for flere svar) (9 svar)

- iPad
- PC
- Mobil
- Xbox
- Playstation
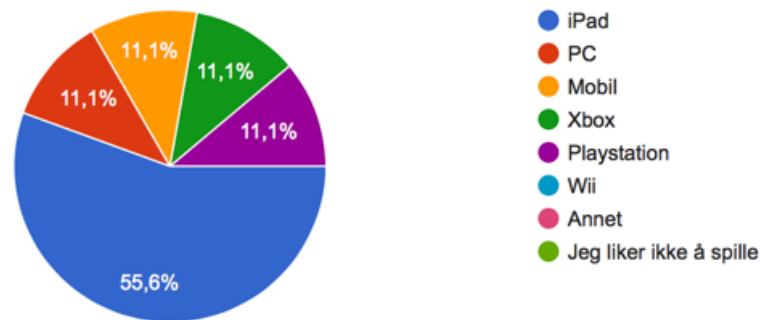- Wii
- Annet
- Jeg liker ikke å spille

Figure 63. Result for question 4

Next, the test-group were asked what type of rewards they would like to receive when they provided correct food and medicine to the goldfish. Also here the questionnaire layout was not correct, as it was intentional multiple-choice answers. In consultation with the teacher, they answered the reward that they would like to receive the most. The result reveals that 55.5% wanted gold coins that they could buy new goldfishes with. Secondly, 22.2 % wanted a surprise and 22.2 % wanted praise. Those who wanted praise were all gendered girls.

Du får belønning hvis du gir riktig mat og medisin til gullfisken. Hvilken belønning liker du best? (Du kan krysse av for flere svar)
(9 svar)

- A) Ord som sier at jeg er flink
- B) Medaljer jeg kan vise til andre
- C) Gullmynter jeg kan kjøpe nye gullfisker med
- D) Medisinkoffert som holder gullfisken frisk i 3 minutter
- E) Musikk
- F) En gratis gullfisk
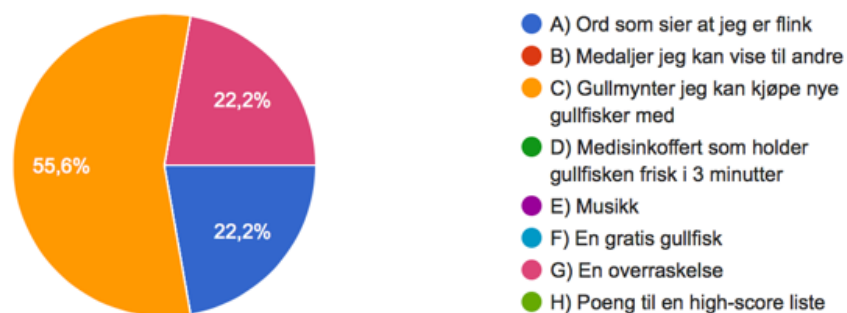- G) En overraskelse
- H) Poeng til en high-score liste

Figure 64. Result for question 5

The result from this question is quite surprising, as it is of similar character as the previous question because of the outgoing multiple-choice answers. Now,

they are asked to choose the one reward that they would like to receive the most. As illustrated in Figure 64, the result has slightly changed from Figure 63. Now, both gold coins and surprise are equally wanted in the test-group with 33.3 % each. Praise is still at 22.2%, and it is the same participants who answered praise in the last question as well. As an entrant, one participant chose the medicine packet instead of gold coins as a change (11.1%).

Hvis du MÅ velge 1 belønning, hvilken belønning liker du best? (9 svar)

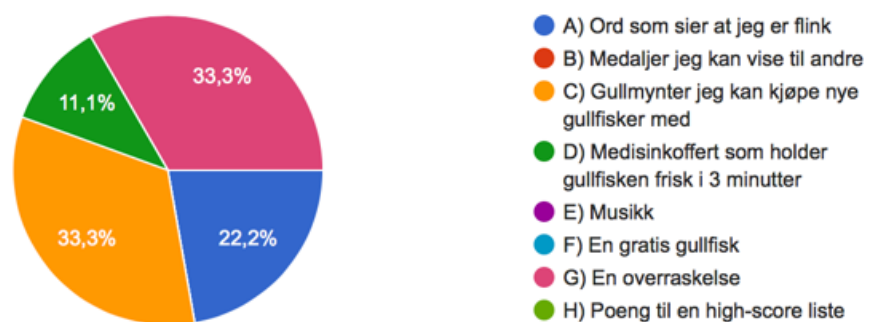*Figure 65. Result for question 6*

When asked what rewards they liked the least, the majority of participants (66,7%) said music. 22,2% answered points to collect to a potential high-score list, and one participant (11,1%) said praise. The participant that answered praise was gendered boy.

Hvilke belønninger liker du minst? (Du kan krysse av for flere svar) (9 svar)
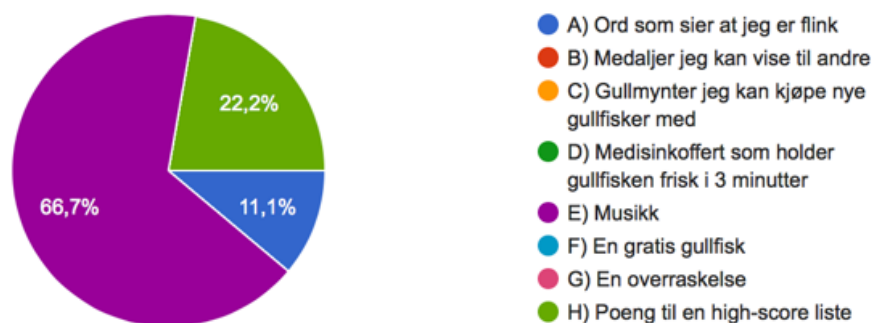
Figure 66. Result for question 7

When asked if they could think of any other rewards that they like in games, two participants contributed. One said simply "no", and the other said "a special goldfish".

Next, the participants were asked *how* they wanted to receive the reward (gold coins) when the goldfish moved to a respective new home. 56,6% said they wanted a fixed payment (fixed reward), while 44,4% said they wanted to try luck and see how much gold coins they could get (variable reward). Only one person differed the outcome.

Hvis en gullfisk flytter til et nytt hjem får du gullmynter. Ønsker du en fast pris som betaling, eller vil du prøve lykken og se hvilken betaling du får?
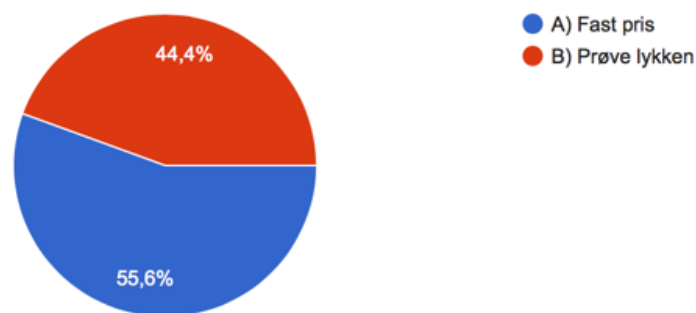(9 svar)

Figure 67. Result for question 9

When asked how they wanted the reward to be scheduled when staying within green-zone of health line, 66,7% answered they wanted the reward after every 5 minutes (fixed interval reward schedule), whilst 33,3% answered that they wanted the reward to arrive suddenly (variable interval reward schedule).

Hvis du holder deg innenfor grønt område blir du belønnet med for eksempel gullpenger. Når ønsker du at belønningen skal komme?
(9 svar)

- A) Etter hvert 5 minutt i grønn sone
- B) Plutselig!

33,3%

66,7%
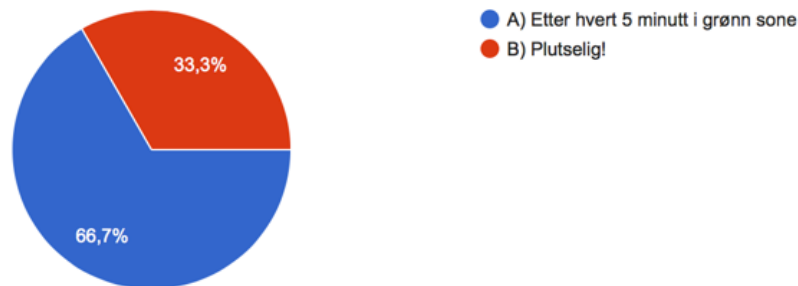
Figure 68. Result for question 10

Next, the participants were asked to answer how they would like to receive the reward if they managed to produce correct meals and medicine three times in a row. The answer suggests that the majority of the participants (89,9%) wanted to spin a lucky wheel and see what reward they got (variable reward), instead of a fixed reward (11,1%).

Hvis du klarer å lage 3 riktige måltider på rad får du belønning. Hvordan vil du få belønningen?
(9 svar)

- A) En fast belønning hver gang, som for eksempel 100 gullmynter
- B) Snurre lykkehjulet og se hvilken belønning jeg får

88,9%

11,1%

Figure 69. Result for question 11

When asked if they would want a free reward every time they start the game, the result was very much alike, with only one person differing the outcome. Note that only 7 of 9 participants answered this question. 57,1% answered that a

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free reward in the beginning of the game would have been fun, but 42,9% answered that they didn't want the reward and wanted to play right away.
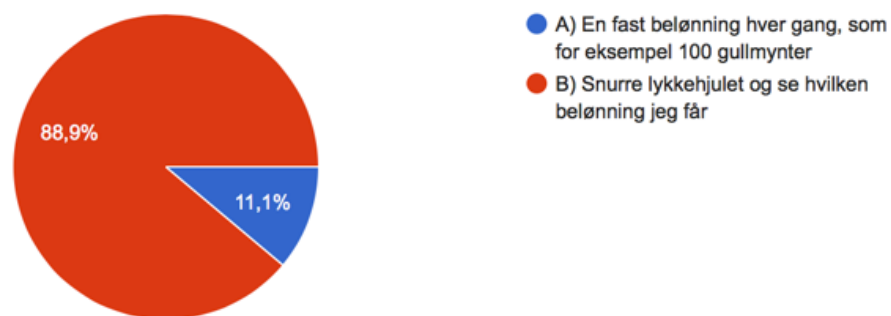
Har du lyst på en gratis belønning med en gang du starter spillet? (7 svar)

- Ja, det hadde vært gøy!
- Nei, jeg har bare lyst til å spille med en gang

42,9%

57,1%
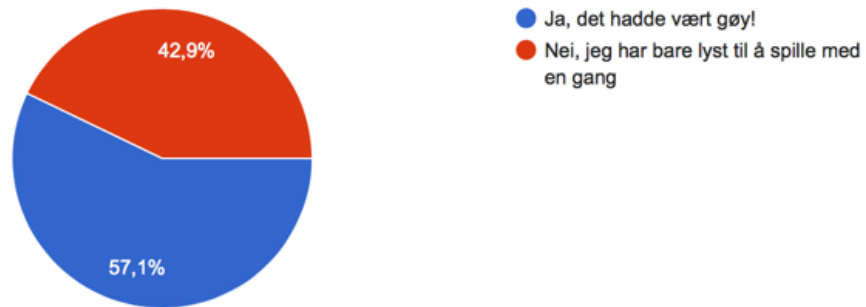
Figure 70. Result to question 12

When asked what the participants thought about having to pay with gold coins if the goldfish had to live in the hospital, all participants who answered this question answered OK to that issue. Note that one participant chose not to answer this question, which is interpreted that the respective person is not sure.

Hvis gullfisken må flytte til sykehuset må du betale for oppholdet i gullmynter. Hva tenker du om det?
(8 svar)

- Det er i orden, da skal jeg passe godt på de andre gullfiskene
- Det er ikke i orden, da vil jeg ikke spille mer

100%

Figure 71. Result to question 13

Question number 14 was related to a thought in a social context that haven't been included in current design, but I was curious to see what they thought of the

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idea. The question was therefore to consider if they would like to be able to fly to other aquariums and chat with the goldfishes living there if they had collected enough rewards of some type. The majority of participants (87,5%) answered "that sounds cool!".

Hvis du har samlet nok belønning (for eksempel medaljer) kan du fly til andre akvarium og chatte med gullfiskene der. Hva tenker du om det?
(8 svar)
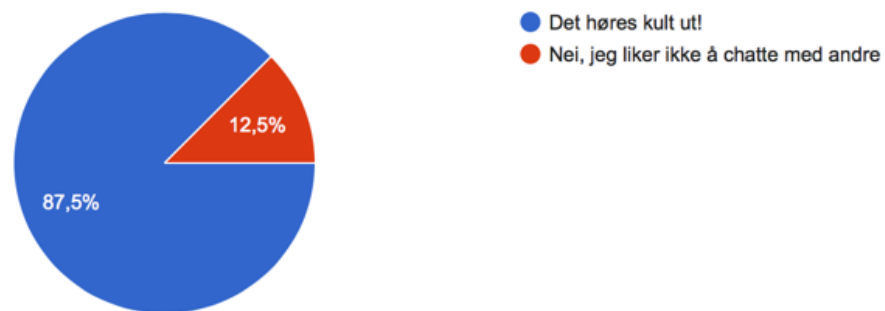
Figure 72. Result to question 14

The next question is if the participants liked the game. 55,6 % answered that they liked the game very much, 33,3% answered that the game was OK, and 11,1% answered that he didn't like the game.

Hva synes du om spillet? (9 svar)
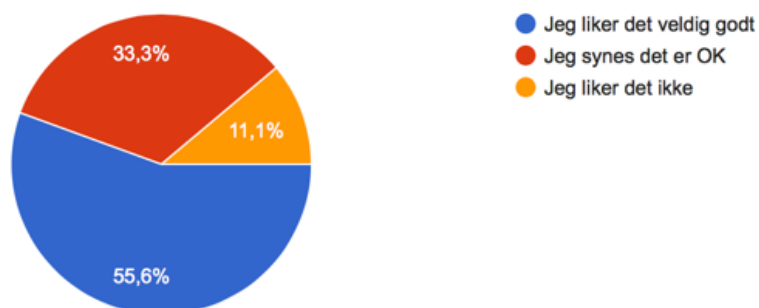
Figure 73. Result to question 15

Further, I asked them if they would like to play the game one day. All of the participants who answered this question answered yes. One participant didn't

answer, which was the same participant that said he didn't like the game. The absence of response from this participant was interpreted that the respective person was not sure.

Kan du tenke deg å prøve spillet en dag? (8 svar)
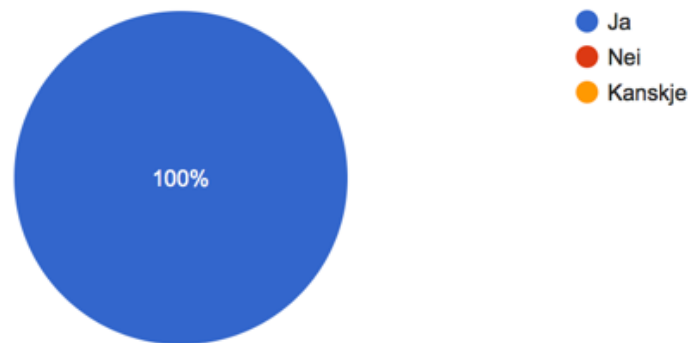
Figure 74. Result to question 16

The next question in the questionnaire was what they thought of the color scheme used in the game. 50% of the participants who answered said that they liked the colors very much, 50% answered that the colors were OK. Note that one participant didn't answer the question, which was again interpreted as the individual was not sure what to answer. No one answered that they didn't like the color scheme.

Hva synes du om fargene i spillet? (8 svar)
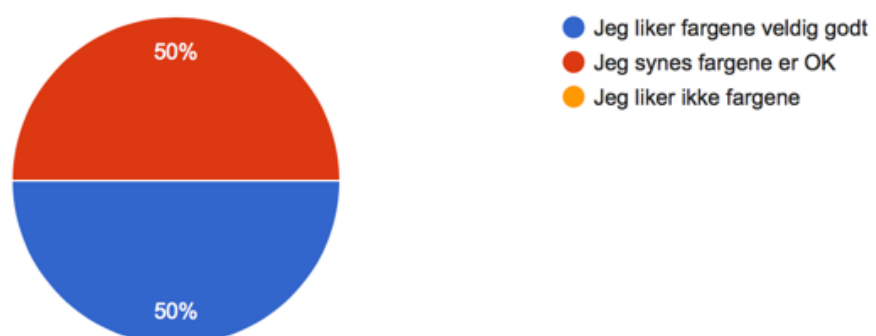
Figure 75. Result to question 17

When asked if they liked that the game outline was within an aquarium, 50% of the participants who answered said that they liked it very much, 50% said that they thought it was OK. Again, one participant didn't answer the questions, which was naturally interpreted that the individual was not sure what to answer. No one said that they didn't like that the story and outline of the game was placed within an aquarium.

Hva synes du om at spillet foregår i et akvarium? (8 svar)
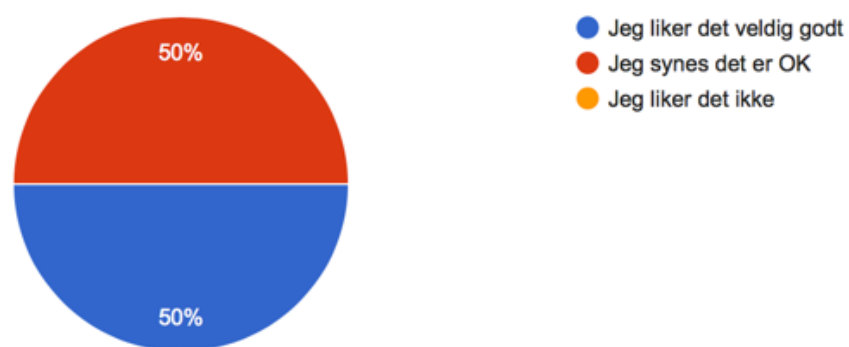
Figure 76. Result to question 18

When asked what the participants thought about goldfishes as game characters, 37,5% said that they liked it very much, 50% said that it was OK, and 12,5 % said that he didn't like it.

Liker du at karakterene i spillet er fisker? (8 svar)
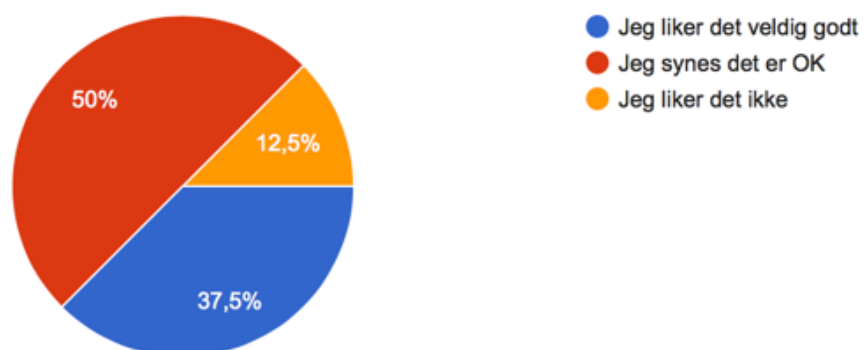
Figure 77. Results to question 19

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The question considering if they liked the images in the game, 37,5% said that they liked them very much, and 62,5% answered that the images was OK. No participants said that they didn't like the images used in the game.

Hva synes du om bildene i spillet? (8 svar)
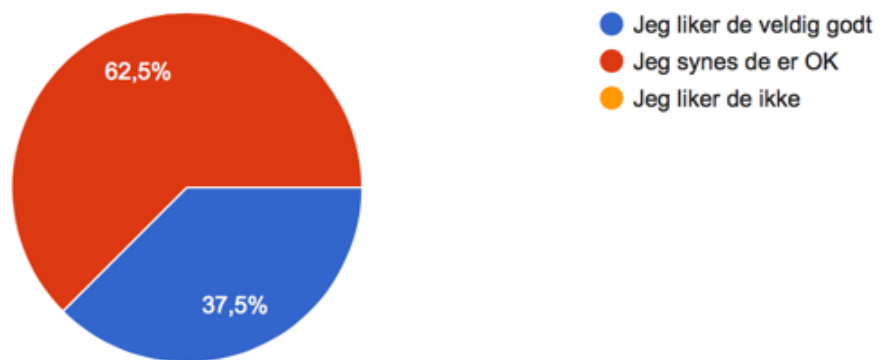
Figure 78. Result to question 20

When asked if the test-group thought that the game looked difficult, 66,7% said no, 22,2% said little, and 11,1% answered yes.

Synes du spillet ser vanskelig ut? (9 svar)
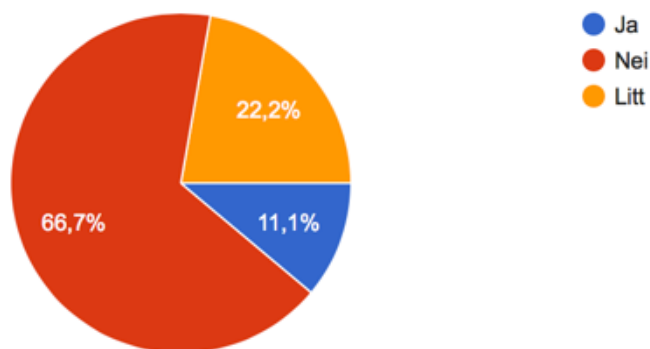
Figure 79. Result to question 21

When asked if the test-group had trouble understanding what the game was about, 66,7% said no, 33,3% said little. No participants answered yes.

Var det vanskelig å forstå hva spillet går ut på? (9 svar)
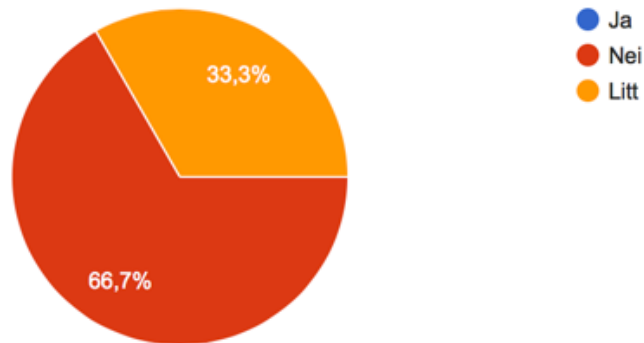
Figure 80. Result to question 22

When asked if the participants had trouble understanding how they could receive rewards in the game, 50% said no, 37,5% said little, 12,5% said yes.

Var det vanskelig å forstå hvordan man får belønning i spillet? (8 svar)
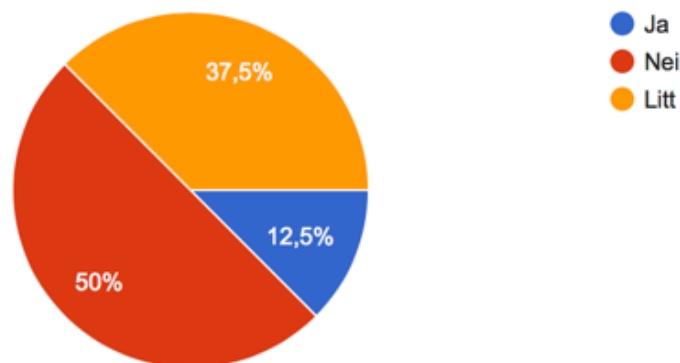
Figure 81. Result to question 23

Finally, I asked the test-group if they had any suggestions of things I could include in the game. Four participants answered. One said simply "no", another said "cat". The third participant said that the characters could be humans instead of goldfishes. The fourth participant said that I could include other types of fishes.

6.3 Summary

This chapter describes the questionnaire in regard to the application and result from this questionnaire. The procedure regarding the questionnaire were explained in details, were the questionnaire consists of four parts. First, a short video of the implemented game was displayed via projector. Thereafter, the complete game outline in detail was presented. Next, questions considering reward preferences within the Diaquarium was conducted. Lastly, usability questions concerning the game were attended. This chapter then presents the results from the questionnaire through use of diagrams and text.

Chapter 7

Discussion

7.1 Findings from Testing

The online questionnaire was held in the end of the project, where I managed to distribute the questions to a class of nine 9-year-old pupils living in Nordland county. The testing was divided into four parts; playing a short movie of the current early prototype, illustrations and high level questions, questions regarding in-game rewards and in-game reward schedules, and questions regarding usability and interest of the game. After this procedure, the test results were analyzed.

Firstly, I want to make it clear that it was a short period of testing, where the result cannot show objective or significant results. Perhaps the most consequential point to address is that the early prototype lacked essential implementation and could not be tested, nor did it contain all parts of the design due to time constraints, whereas some of the game elements had to be simplified (e.g., existing food plates instead of drag-and-drop food items as well as no insulin management). Also, the early prototype lacked main motivational gameplay features and rewards, which are the key elements of the educational effect of the game. As a result, only images with describing text and a short movie of the early prototype was displayed to explain the game outline to the potential user group so that they would have enough information to answer the questions. This could influence the overall impression the users had about the game, and it also adds a factor of difficulty knowing what the children actually understood of the presented information of the game.

Most pupils answered that they liked goldfishes when asked, and there were n=0 participants who answered that they didn't like goldfishes at all. I was informed afterwards by the teacher that these pupils regularly play a computer game in math class where the characters are fishes. The potential user group in this test were therefore familiar with fish as characters in games. Also, because of

this familiarity, it is possible that they associate fish in games with something fun and have positive expectations regarding the project game.

N=0 of the pupils in the test group answered that they didn't like to play games, and n=9 answered devices that they used when playing games. This result suggests that they are all quite experienced in game-playing, which is confirmed when the teacher notifies that her pupils play educational games at school on a regularly basis.

When asked what type of rewards they would like to receive when they managed to provide correct food and medicine to the goldfish, it was intentional to have multiple-choice answers. However, as mentioned earlier, the questionnaire set up was not correct, and the pupils were, therefore, only able to choose one answer. The results reveals that approximately half of all the pupils wanted to receive gold coins that they could use to buy new goldfishes with. This was as expected, as gold coins were represented as the only resource for progression in the gameplay (e.g., the only reward that could buy goldfishes). The rest of the pupils wanted either praise or a surprise to honor the correct action accomplished.

Praise is a well-known attribute in in-game rewards, where this answer suggests correlation to children's' need for recognition and explicit reinsurance that they managed correct action. It is important to clarify that the concept of praise in this project is addressed as a type of feedback and acknowledgement.

For those pupils who answered surprise as the desired reward, it suggests that the excitement when considering an unknown reward is so strong that they would potentially risk getting (what they would consider) a bad reward for the thrill of it. According to Johnson (2013), elements of surprise and unexpected rewards keep players engaged, pushing them through a tough level and lead them to mastery. This is confirmed in a later question, where n=9 would rather be rewarded spinning a lucky wheel to see what reward they will get, instead of a static reward of gold coins, which would have been a safe choice regarding progression in gameplay.

It is interesting to see that for the next question, regarding what reward they would like the most (which is similar to the previous question due to lack of multiple-choice answers), n=2 of the participants decided to answer a different

type of reward. They had both answered gold coins as the reward they liked the most in the previous question, but now, n=1 of participant went for the surprise reward, and n=1 wanted a medicine packet to keep the goldfish healthy for 3 minutes. These answers exemplify one of the biggest difficulties game designers and developers faces: users' decisions and opinions regarding what they like can immediately change due to their personal preferences. This specific challenge for game designers and developers is also evident when comparing the least wanted rewards. Most of the participants answered music as the most minimal reward of all rewards presented, but some of them also answered points used in a high score list and praise. Recap to the previous answers, praise was one of the most wanted reward for some of the participants.

There is only one question in the questionnaire regarding reward schedules. It asks how they want to receive rewards when they have managed to stay within the green zone of the glucose barometer. The plurality of the participants answered that they preferred static reward (e.g., reward after 5 minutes within green zone). These answers contradict the reward schedule literature that claims that the variable interval reward schedule is more attractive than the fixed interval reward schedule, because the users never know when the next reward arrives. According to Sylvester (2013), fixed reward ratio schedules are poor motivators, because they encourage long periods of inactivity, waiting for the next reward. It is in these long periods of inactivity that players easily get up and walk away from the game (Sylvester, 2013). Variable reward ratio schedules, on the other hand, are the most powerful simple motivator of all schedules (2013), because it will keep players playing. Since there always will be a chance to get a reward the next time, players will continue gameplay, hoping the next enemy will drop the big payoff (Sylvester, 2013). However, there are only one question regarding reward schedules in the questionnaire, and the answer is therefore far from trustworthy, as there is little knowledge regarding how the users perceived the question due to no actual testing in the game itself. The answer also differs when comparing to the answers where most of the participants preferred rewards of surprising features, which can correlate to variable interval reward schedule. Whether they understood the concept or not is, therefore, questionable. It is therefore noticed that there should

have been several more questions regarding preferred reward schedules. Also, a working prototype would have illustrated this problem more clearly for the users.

I then asked what they thought about negative reinforcement in light of having to pay for the goldfish hospital stay. To my surprise, n=8 of participant chose answers that articulated OK. This result strengthens the literature that suggests that negative reinforcement doesn't lead to negative emotions intermittently, but instead the players respond to failures with excitement, interest, and joy, getting highly motivated to return to the task being optimistic about reaching their goals (Granic *et al.,* 2014).

One question investigated the social aspect of Diaquarium that was considered to be integrated as a component within the game for future work. Even though it isn't part of the current design, I wanted to see if the children liked the concept, where they could be able to transport to other aquariums and chat with other goldfishes. Of all participants answering the question, n=7 were positive to the idea, which suggests that the Diaquarium surely has the potential to have some sort of social components included in the game outline. Social aspects are considered to exist as a functionality of serious games that can enhance play personalization and interactivity (Konert *et al.,* 2012).

The next answers regarding usability and interest of the game suggests that approximately half of the participants like the Diaquarium very much. N=3 of the participants answered that the game was OK, and n=1 answered that he didn't like the game at all. It would have been really interesting to conduct further questionnaires to find out exactly what he didn't like about the game or why it was only considered OK. However, when asked if they would like to play the game one day, n=8 answered yes. N=1 who answered that he didn't like the game at all did not answer this question, which is interpreted that he perhaps was not sure if he would like or not like to play the Diaquarium one day. The teacher told me afterwards that her pupils had begged her to get the game so that they could try it out. To stop them from nagging, she had answered that they could play the game one day. To me, this was an incredible feedback to receive, strengthening the potential of the game. This type of information implies that the Diaquarium had

perhaps awakened some interests and curiosity within these children, which was considered a high desire when designing and developing the game.

Questions about colors and game story line taking place in an aquarium were answered fifty-fifty on both questions that they liked them very much and that they were OK, e.g., n=0 of the participants claimed that they didn't like either color or environment of the story line. However, a question that examined if the potential user group liked that the game characters were fish, n=1 claimed that he didn't like it at all. Later, the same boy answered that the characters could be human beings instead of goldfishes when asked if they had any other suggestions. This implies that the theme in this particular game is perhaps too childish in respect to the intended user group, or that it doesn't fit his interests, and is certainly an issue that must be addressed in future research and tests. On the other side, only n=1 of all participants provided this type of answer, and as addressed earlier, this type of answer can be rooted in their personal preferences.

Further, the answers regarding usability brings the idea that the plural of participant thinks that the game looks not too difficult, and that they mostly understand how they can achieve rewards. However, n=1 answered that he thought the game look difficult and he didn't understand how he could receive rewards. If more time, this answer must have been further explored to see what caused this confusion and why he perceived the game as difficult. It is not implicit that the game itself is difficult, but perhaps the images and only presented the video of the early prototype was unclear to start with. Overall, the Diaquarium has seemingly high usability for the potential user-group according to the test result from the questionnaire.

7.2 Critical Points and Decisions

This chapter will discuss crucial points that came up throughout this project, as well as decisions made, that composed led to the outcome of the Diaquarium. This chapter provides qualitative discussions regarding different alternatives for various critical situations, while argue and justify why some of the decisions were made.

When I first came up with the idea of the Diaquarium, I created some illustrations to mainly clarify the concept to the supervisors (see chapter 5.6). It was mainly to show the approach, explain what I meant, and see if the idea was master thesis material. The illustrations were not thoroughly thought out, as they were just drawings from a late night before, but these illustrations became the foundation regarding the game outline and main game mechanisms for the potential prototype. When I started the research project, I had the respective drawings in the back of my mind, knowing that the future game would possibly evolve from these ideas and concepts.

During the literature search and review, I found various learning and motivation theories addressing different approaches to explain the respective fields. However, deciding which of these theories would be appropriate for this thesis was rather hard. I therefore contacted associate professor and psychologist Phful for some help, who advised me to look at reinforcement learning and cognitive/computational motivation theories. It appeared that reinforcement learning and games have a long and mutually beneficial common history, where allot of successful games have applied reinforcement learning in their practice (Szita, 2012). In 2012, Steinkuehler *et al.* suggested that video games are about doing, decision making, problem solving, and interacting. All mechanisms which can be correlated to reinforcement learning, where reinforcement learning allows an agent to learn its behavior based on feedback from the environment such as in a video game. Steinkuehler *et al.* (2012) confirms this comparison, as they imply that learning is a core mechanism within all good games, as players must learn some kind of behavior or knowledge in order to get to the next level of the game. Players must use their previous knowledge or skill in problem solving, the quality of one's choices and decisions, considering short- and long-term consequences, and preparation for future learning (Steinkuehler *et al.*, 2012). Video games can also be seen as a goal-directed competitive activity that is conducted within a framework of agreed rules (Wouters *et al.,* 2009), where individuals play against the computer, other players, or oneself. Also, the design and production of games involves aspects of, among others, cognitive psychology (Koster, 2013). The game is, inter alia, designed in perspective of model-based learning, as the child would

then understand the structure of the game and hence know why he or she are being rewarded. Therefore, players would be able to reinforce and change behavior, related to self-management skills, regarding Diabetes Mellitus, as the main goal is to make decisions throughout the gameplay that potentially increases future rewards. The Diaquarium is constructed accordingly to the model-based approach in reinforcement learning, where users can predict the next state and reward, e.g., players are rewarded when performing correct actions. With a proper model-based approach, children will, for example, be able to predict rewards when they manage to stay within green zone of the health line through managing correct meals and medicine.

During this project, it was desired to gather feedback from potential users in addition to assemble research literature. I therefore decided from early on that I was going to arrange some kind of questionnaire and test scenario during the project. The first issue was whether to include children with Type 1 Diabetes Mellitus or not. In the beginning of this thesis, I acknowledge that there are in total 18 children under age 18 with the ailment who are being treated at the University Hospital of North Norway (Skrivarhaug *et al.,* 2015). In 2013, Makhlysheva completed her 1-year master thesis, where she developed a serious game for children with Type 1 Diabetes Mellitus, and was only able to conduct tests on 1 of the 18 children with the ailment. I could potentially specify that the test group had to consist solely of children with Type 1 Diabetes Mellitus since the game is tailored this particular group, but then I would risk getting little or no feedback at all in light of Alexandra's experience. The decision to include children without the ailment in the potential test group was settled with supervisor Hartvigsen, where the rationale for that decision was grounded on the main view of rewards in this thesis, where rewards, learning, and motivation theories does not differ for children with or without the ailment.

There are several potential practices regarding feedback collection in serious games, where I, for this thesis, considered gather potential users to carry out tests and questionnaires as well as distribute online questionnaires. A physical gathering of potential users for tests and questionnaires are reasonable, as it makes it highly possible for game developers to assure the test group with

information if something is unclear, answer questions, and ask questions if something comes up. However, it is not considered practical or effective, as users have to spend their spare time to transport themselves and gather in locations. Also, finding locations to carry out this type of test and questionnaires can be challenging. Due to time constraints, I decided to reject this practice, and, instead, distribute online questionnaires. The logic behind this particular choice was due to the possibility of sharing the questionnaire independently and without restriction in location. I wanted to hand out the questionnaire along with a movie of the early prototype to as many potential users as possible, but due to restraints in time, I decided to contact a teacher in North of Norway with pupils within the intended age group for the Diaquarium, and distributed the online questionnaire to them. For a moment, I also considered to hand out the questionnaire to parents who were active on the social medias, such as facebook, to collect a greater amount of feedback from potential users. However, this idea was not conducted due to the fact that there was no obvious reassurance that the person answering the questionnaire actually were children within intended age-group.

When I distributed the questionnaire to the teacher and her pupils, I had only managed to develop an early prototype of the Diaquarium containing merely the core game features. Some of the overall game concept was in place, but the game itself still remained a lot of work before being able to play, and none of the reward functionalities were applied. The presented rewards in the questionnaire were based on the literature regarding reward categories and schedules that could potentially be applied in the Diaquarium. I designed eight different types of rewards that were appropriate for the game; praise, medals, gold coins, medicine packet, sound/music, free goldfish, surprise, and points. The determination of what rewards to include in the Diaquarium was based on research literature, the analysis from test results, as well as acknowledgement of decisions made throughout the process.

Praise is a type of reward that is mentioned by various of researchers (Hallford & Hallford, 2001; Schell, 2008; Wang & Sun, 2011). The reward itself has nothing to do with the game-play, but act as a feedback message in response to successful actions and create positive emotions, and I therefore decided to suggest

praise as an in-game reward within the Diaquarium. The result from test group revealed that this type of reward was both highly wanted and one of the least wanted reward. Standing at a crucial point, deciding whether to include it or not in the Diaquarium, I made a decision to apply it in the design as one of the in-game rewards. The logic behind this decision was based on the assumption that the least wanted reward did not necessarily equal a reward that they didn't want at all. Therefore, the answers regarding the rewards that was considered most wanted was valued higher and thus included in the design. It would have been more resourceful if I included one question regarding if any of the rewards was specified as not wanted at all in the questionnaire. This acknowledgement shall be considered in future questionnaires.

Next, medals were suggested as an in-game reward, where the purpose of medals were specified as something you could show to others. The logic behind including medals in the Diaquarium as an in-game reward was due to the fact that they are rewards of glory (Hallford & Hallford, 2001), similar to praise, but also collectable as a measurement of success (Schell, 2008). The test group didn't choose medals as the most wanted reward, nor the least wanted reward. Thus, it was not prioritized as an in-game reward during these iterations of design and development.

Gold coins was presented as a possible reward of resource, as the potential user group were informed that gold coins could buy new goldfishes. It fits in Hallford & Hallford (2001) classification "rewards of access", as it can be viewed as a tool used to access resources (goldfishes) within the game. Schell (2008), Wang and Sun (2011) mentions resources as something that can be collected and used to affect gameplay, such as virtual money that can be spent to buy new goldfishes. It was thought as essential to include a reward of resource to the Diaquarium in order to create prolong play, and gold coins was therefore suggested as an attribute to keep progression in the game. The test group responded highly to this type of reward, and gold coins was the most wanted reward of all when asked. It was therefore highly prioritized and thus included in the game design in several fields to reward correct behavior.

Thereafter, a medicine packet reward was proposed as a potential in-game reward feature, categorized as a rewards of sustenance (Hallford & Hallford, 2001) and prolonged play (Schell, 2008). It can also be seen as a reward of resources (Schell, 2008), due to the possibility to be used to enhance the gameplay. Considering a reward that affects character health in a positive way without much effort was suggested to potentially increase motivation while attempting to retrieve it. N=1 of the participants in the test group answered medicine pack as one of the most wanted reward, and therefore it was included in the design. The time duration of medicine packet effect was reduced to 1 minute to not create an open window where potential users could leave the game because the gameplay became boring with nothing to do.

Further, I chose to propose sound/music as a reward in the Diaquarium, though only mentioned by Schell (2008) as a reward of spectacle. Both Wang, Sun (2011) and Oxland (2004) suggests visual rewards (e.g., explosions and special effects when defeated an enemy) to provide sense of fun as well as marking an achievement, where I claim that sounds can provide the same function (for example, when players have managed to provide correct food and meals). It can also serve as a method to provide feedback, as it can easily demonstrate if the action made was wrong (for example a "dong"-sound) or correct (for example a "ding"-sound). This reward was one of the least wanted reward of all within the test group. It was therefore considered important in future work to include some kind of background music and use music as a feedback tool, but not alone as a reward for some action.

Additionally, a free goldfish was submitted as a potential reward in the Diaquarium. Being benefited with a goldfish without having to spend any earned resources when accomplished correct actions was suggested to be a motivational, and can be recognized as a reward of access (Hallford & Hallford, 2001) and prolonged play (Schell, 2008). However, this type of reward seemingly didn't attract the test group, as no one chose this opportunity as the best reward they could imagine, nor the worst. The reason for this could be the fact that being handed a free goldfish when accomplished a correct action could potentially become a negative attribute, where having an extra goldfish can cause some sort of chaos,

dysfunction in the aquarium, and add a fact of risk. Without specifying that this type of reward is optional, it can even be unethical as an in-game reward, as it is pushed unto users without having their consent. Free goldfish was therefore only included as a potential reward in the welcome mystery box, as it was suggested that taking care of 1 and 2 goldfishes in the beginning should be feasible for children in the intended user group. This must be tested in future work of rewards in the Diaquarium. If tests reveilles that potential users are not able to take care of two goldfishes in the game start, due to difficulty, this reward has to be removed from the original design of the game.

Surprise is a type of random rewards, also known as a mystery box (Chou, 2013), where users are rewarded, but they don't necessarily know what the reward is. According to Chou (2013), not knowing can enhance engagement because users are aware that they will be surprised by whatever they end up with. The test group responded positively to the surprise rewards in the questionnaire, whereas surprise scored high when asked what type of reward they wanted the most, as well as when asked how they wanted to get payed when a goldfish is moved to a new home, where 44,5 % answered that they wanted to try the luck (e.g., surprise according to price). Therefore, a surprise was included in the game design as a welcome reward to attract users to come back and play more by reinforcing the behavior of returning/starting the game. Based on the high interest in surprise as reward in test group, it was suggested that children want to return to be surprised to see what they will get next.

Being rewarded with points to display in a potential high-score list was answered as one of the least wanted reward according to the test group in this project. Points in this context can be associated with status and comparison (Wang & Sun, 2011), but makes no difference in the gameplay (Hallford & Hallford, 2001) and is only used to measure success and performance (Schell, 2008; Wang & Sun, 2011). Due to the fact that points were listed as one of the least wanted reward, it was decided to not include it in the game design. It is suggested that the test group was not motivated by rewards that could be used as comparison of performance, as they answered points to high score list as one of the least wanted reward as well as discarding medals (also in the comparison category) as an answer at all.

Due to the fact that rewards regarding free goldfish, medals and points were not included in the main in-game reward design, it was desirable to create an additional reward for the Diaquarium. Therefore, a super power reward was designed, where the super power slows the process of increase or decrease in blood sugar levels for 1 minute when the reward is received. This type of reward had not yet been tested on a potential test group, and was therefore left for future work. However, it was suggested to be motivational, as it serves a purpose in the game and can potentially provide progression in the gameplay.

One of the questions in the questionnaire asked if the children had any other ideas that they would like to share. One of the children answered that it would be nice to have various types of goldfishes. This was a valuable feedback, as it was integrated in the design as a reward, where users are being rewarded with unlocking new types of goldfish. It was also considered to create a type of reward where the users could personalize their goldfish by choosing different colors, funny hats, etc. Due to time constraints, this was not included in the game design of these iterations, but rather mentioned in the future work section in Chapter 8.

Negative rewards were also considered in this thesis, as they were thought to guide users in correct direction. When users provide bad meals and/or wrong amount of insulin, the goldfish gives feedback that it was not appreciated. Also, having a goldfish for too long within red or yellow zone in the health line was an action that was suggested to be corrected, and it was decided to create a story where the goldfish was removed from the Diaquarium to live in the hospital. In the beginning, thoughts regarding deaths were considered, but was rejected, for the reason that children who have just been diagnosed with Diabetes Mellitus does not necessarily know all severe consequences of bad self-management, and also, death was considered to be demotivating for young users. When asked if the children were fine with the story of moving to a hospital and pay for the goldfish to stay there, all answered yes. This type of negative reinforcement was therefore designed and included in the gameplay of the Diaquarium.

During 2012-2014, Makhlysheva *et al.* (2016) acknowledged 155 diabetes-related games in their review of serious games for people with Diabetes. They, among others, identified that the number of new games for Diabetes patients was

less in 2014 than in 2012 and 2013 (Makhlysheva *et al.,* 2016), indicating a decline in popularity of diabetes-related serious games. Even though research suggests that fewer diabetes-related serious games were produced in 2014 than previous years, the serious game market in its entirety is definitely on the raise. The industry is expected to have a compound annual growth rate of 16.38% between 2015 and 2020, and by 2020, the market will be worth $5,448.82 million (MarketsandMarkets, 2016). Despite the decent number of serious games for children with Type 1 Diabetes Mellitus and increased growth of serious games, I failed to find any overview of the best and/or most played serious game for children with Diabetes Mellitus, nor any information regarding normal value of rewards in games. This information was anticipated, as designing and exploring in-game rewards in the Diaquarium would have been rooted in the average proper serious game in light of rewards and reward schedules. Therefore, three random games were chosen and presented as related games, their rewards have been addressed, and the results have been taken into consideration during this project.

When drawing the first draft and version of the Diaquarium, the ideas was not completely though out. Therefore, during implementation, it was recognized that I had to make some changes regarding the design. Mainly, it considered the background story being presented in a small square within the Diaquarium. Due to the fact that the intended age group was not experts in reading, and for the background story to be complete, it was decided to create a new scene where Otis the goldfish presents the background story, little by little, using speech bobbles. Another feature that had to be fixed regarding usability was the goldfish information. In the older versions, the information was presented in small square attached to the respective goldfish. However, while I was developing the game, I realized that the square took too much information and could possibly cause confusion regarding which goldfish the information belonged to. Therefore, I decided to implement the health line along with important information along the bottom line of the screen, as it appeared more tidy and intuitive for the potential users.

7.2 Overall Thoughts

During this project, a question keeps coming up while doing research: are serious games too serious? This questions roots in the research found, all addressing how much learning a serious game can provide and if/how rewards can enhance this learning. These are all great questions that must be answered and evaluated, but if the game is not considered funny or enjoyable within the potential user group, there is no breakthrough for that particular serious game. The literature and research regarding in-game rewards and reward schedules were limited or absent, which made me turn to the commercial part of the game industry, who has more research on this type of field. The reason is suggested to correlate to the fact that these games are designed and developed solely for pleasure.

The motivational literature addresses intrinsic and extrinsic motivation, where it has been address later in this thesis that extrinsic motivation can potentially lower intrinsic motivation, where intrinsic motivation is highly preferable in light of learning. The reward itself is considered to increase extrinsic motivation, but can in-game rewards also increase intrinsic motivation? Rewards in games are mechanisms that is contributable to make games fun and enjoyable, makes children want to play the game because it brings them pleasure, which is considered an intrinsic motivation. If a person is intrinsic motivated to learn about diabetes-related information, they would most likely know why they are learning such information. It is suggested that children who has recently been diagnosed with Type 1Diabetes Mellitus are too young and too unexperienced to understand the consequences of their disease and therefore not intrinsically motivated in the same way as the example above. Therefore, it is suggested that children can start to be high on extrinsic motivation, where they want to play the game and retrieve different in-game rewards, and then gradually develop understanding of the field and thereby increase intrinsic motivation because they realize the importance and their interest in field that regards their lifestyle. A reward outside the game, however, would place the situation differently. A child that finds the game enjoyable and funny (high on intrinsic motivation), but is promised a toy if he or

she finish a certain action (high on extrinsic motivation), can potentially reduce intrinsic motivation due to the high extrinsic motivation.

Also, I find it very interesting that industries outside the gaming industry have in recent years been more curious regarding in-game mechanisms and how they increase motivation among players, where some of these businesses has adopted these structures into their own field (gamification). It appears that most businesses pay attention to the commercial part of the game market, and to my knowledge, not so much to the serious game market. To me, this is an interesting observation, as it would appear as more natural if they were observing the serious game market approach since they also regard learning. It would be very interesting to include recognized gamification techniques in a serious game to see if motivation and interest increases.

7.3 Summary

This chapter discusses the results from the research, as well as the answers from the questionnaire regarding the Diaquarium, where these findings are discussed. Also, critical points and following decisions are addressed and discussed. The implementation of the system is also described in this chapter. Lastly, some overall thoughts that the author had notified during this thesis has been mentioned in a short discussion.

Chapter 8

Concluding Remarks and Future Work

8.1 Conclusion

The main research problem addressed in the beginning of this thesis was to explore in-game rewards in serious games, and apply these techniques in an educational game that was designed and implemented to help children with Type 1 Diabetes Mellitus to improve their self-management skills. The major goal was to address various reward techniques used in games and address how they can be applied to prevent children from quitting gameplay, and consequently loose significant information and knowledge related to Diabetes. Serious games with characteristics to be fully engaging and motivational for children can likely help them to avoid short-term and long-term disease complications in the future. As a result, the Diaquarium was designed to explore these problems. Also, an early prototype was implemented to illustrate the main characteristics of the game itself.

The design of the Diaquarium is achieved by identifications of significance in-game rewards, game features, and psychological behavior regarding learning and motivation. Also, feedback and suggestions from a potential user group, professors in field of game development, professors in field of psychology, experts in Diabetes Mellitus, as well as knowledge from workshops, were considered during the process of designing the Diabetes.

Diabetes-related knowledge was integrated into the Diaquarium gameplay, where users of the application enhance knowledge in respect to interaction regarding food, insulin, emotions, and blood sugar levels for individuals with the disease through the main story of the game.

In the final stage of the project, a questionnaire was distributed to a class of nine 9-year-old children in Nordland County. Due to time constraints, too short time creating the questionnaire, too short time distributing it to potential users,

as well as no working prototype to test the game on users resulted in no significant results. Despite, answers retrieved from the questionnaire demonstrated that the Diaquarium can be considered as an attractive and moderately difficult game. The outcome from the questionnaire implies that least or most wanted rewards often are results of personal preference, but the result also shows suggestions that some of the rewards presented was more/less wanted than others within the whole group of potential users. The most wanted rewards were considered a resource within the game as well as being surprising to the users. The least wanted reward was sound/music, where n=6 agreed that this was not a reward they highly desired.

The conclusion regarding sub-questions for Chapter 1 will be presented below.

Q1:   What types of rewards and reward techniques exist in games?

The relevant literature studied several types of rewards and reward techniques that can be applied in games. In total, 36 types/categories of in-game rewards and 6 in-game reward schedules were addressed and collected in a table along with descriptions for each and every one.

Q2:   What qualifies a good reward technique in games?

A good reward technique acknowledges appropriate reward types/categories that can be applied in the game story, where the reward shall serve purpose within the game and/or to the intended users' preferences. Wanted and least wanted rewards differs for age groups and cultures, which are characteristics that shall be addressed to seamlessly fit the system. A good reward technique assures that there are no gaps in motivation that could possibly create windows where players decides to stop playing (Sylvester, 2013). Thus, good reward techniques shall always run several rewards and reward schedules at the same time, so that whenever one schedule reach motivation bottom, the others are at their motivation peak, to eliminate these motivational dips in gameplay.

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Q3: How can rewards in games be applied in the best way?

Rewards in games shall reinforce behavior, actions and decisions made throughout to increase users learning and knowledge, as well as increase motivation. Rewards should therefore be applied after gameplay action, so that the users know exactly *why* they are being rewarded and therefore are able to determinate outcome of decisions made. According to test results, rewards that surprises users seems to be highly engaging.

Q4: What are most important behaviors required in self-management of Type 1 Diabetes Mellitus?

The most important behaviors required in self-management of Type 1 Diabetes Mellitus were in this thesis addressed as:

- Healthy eating
- Being active
- Monitoring blood glucose, blood pressure, urine ketones, and weight
- Problem solving
- Reducing risk
- Health coping

Q5: How can behaviors required in self-management of Type 1 Diabetes Mellitus be presented in a game?

The Diaquarium demonstrates how healthy eating behavior and blood glucose monitoring can be applied in a serious game, which are some of the acknowledged important behaviors required in self-management of Type 1 Diabetes Mellitus. The game solved this problem by applying Diabetes Mellitus to the main characters in the game, and let these characters demonstrate Diabetes-related behaviors, where self-treatment behaviors had to be performed in order to have progression in gameplay.

8.2 Thesis Contribution

Overview of existing in-game rewards and in-game reward schedules

This project contains an overview of existing in-game rewards and in-game reward schedules that can be used in future game projects and research when considering reinforcement techniques.

Early prototype of a promising serious game

This thesis provides an early prototype of a promising serious game for children with Type 1 Diabetes Mellitus, demonstrating its main features and game mechanisms.

Positive test results

The result from the questionnaire conducted at the end of this project demonstrated an attractive and appealing serious game, that n=8 participants answered that they would like to try some day. Also, the teacher informed me after the test was completed, that the children were begging her to distribute the game so they could play it, and to stop their nagging had to say that they could play it one day. This illustrates that the game has high potential among the potential user group.

However, due to the fact that the test group only watched a short movie of the early prototype and were enhanced with the rest of the game story and mechanisms through illustrations and text, it is difficult to decide whether they actually understood the concept or not. Due to the fact that the test group only contained nine children with approximately same age, and due to limited time for testing, the results cannot be regarded as significant.

Bring attention to gaps in literature

According to the author, there are little existing literature and research regarding in-game rewards, in-game reward techniques, and how different rewards affect behavior and motivation among the system users. This thesis therefore bring

attention to this gap in literature that must be considered further to get the maximum use of serious games, where maximum use is referred to players completing games without any withdraws.

Reusable project results

The game design, requirements, sprites/illustrations and implementation of the early prototype can possibly be used in other projects when this thesis is completed.

8.3 Future Work

Game development usually takes 12-24 months of work with various people involved, such as lead designer, project leader, software planner, architectural lead, programmer artists, level designers, and testers (Claypool, 2008). This project took place in barely 4 months with one person responsible for all these fields of a game development, provoking project limitations due to time constraints. A great deal of this project is therefore left for future work, and will be addressed further in this sub-chapter.

Usually, one of the main goal for games is to be published, played and appreciated by intended users. Before the Diaquarium can be published and help children with Type 1 Diabetes Mellitus with their self-treatment skills, several more iterations are needed regarding design, tests, and development.

An extended design process exploring comprehensive various types of rewards and reward schedules are necessary. The rewards designed and presented in this thesis only covers some of the types/categories and schedules addressed in the overview. Therefore, designing various rewards from the resisting types/categories and schedules that has not yet been attended in the Diaquarium are essential to detect the rewards that are found highly motivating for the potential user group. Such rewards could for example be reward of access (Hallford & Hallford, 2001), where users are being rewarded with access to game objects that they didn't have before. Examples of such rewards could be personalizing each goldfish with a new appearance or ability that they didn't have before, like for example ability to change colors, wear funny hats, swimming in loops, dance, etc.

These rewards should then be conferred with the potential user group to see if they are found desirable and motivational, or not. If they are, they shall be applied in the Diaquarium. If not, they will be discarded and new rewards must be considered. In short, there still remain work regarding exploring in-game rewards in the Diaquarium.

Also, designing some sort of social component in the Diaquarium is highly desired, where the test group from current project were highly motivated and positive to this suggestion. Due to time constraints, this feature had to be left for future work. The main idea is to create a network of aquariums, where goldfishes are able to visit other aquariums, share thoughts and other diabetes-related reflections through chat, stickers, likes, and other expressive features. Social components in games are connecting children in the same situation across the world, that in other ways would not have occurred. Having someone to talk to that experiences the same difficulties as themselves can enlighten the situation, where socialization is known to prevent mental health diseases (Marano, 2003). Having a social component in a serious game can make users feel that they are a part of something larger than themselves, feel supported by others, wards of loneliness and distraction from pain, feel wanted, and provides a place where users can confide their ideas and feelings (Dombeck, 2006). If the Diaquarium in future exists with such social feature, social treasures (Chou, 2013) can be applied as a reward, where users get rewards from other users within the game. These rewards cannot be earned, not be found, but must be given by another individual playing the game. This can potentially boost the game popularity, as serious players want to receive these rewards and therefore spread the word so others can join the game and give the highly desired rewards to them.

The sprites and animations used in this game are all designed and drawn by the author. It displays some plain 2D graphics with simple animations. To increase the overall game experience, these sprites and animations can be arranged on further with a lower level of details, such as movement of goldfish fins, blinking eyes, movement of mouth, bubbles coming out from their mouths, etc. Also, background music and sound effect shall be applied in the Diaquarium to enhance the overall experience further more.

All new design changes shall be implemented in future work, creating various version of the application. Currently, only an early prototype exists showing some of the main functionalities in the game, and the Diaquarium therefore requires implementation for testing various versions among potential users and, eventually after many iterations, launch the game.

Furthermore, quality testing and questionnaires must be the main topic during the design and implementation process. Test of the actual game through different versions will provide more correct feedback of the user game experience, unlike illustrations and movies. Having users playing the game also detects usability problems, bugs, and other specific components in the game that can be changed during the next version. Tests and questionnaires should be applied both online (to reach out to a big audience), as well as in physical gatherings (to see the response and being able to clarify questions that can occur during the test process). The test group must contain a large amount of potential users within the target audience, and should include both children with and without Type 1 Diabetes Mellitus to show significance regarding the test and questionnaire outcome. When the Diaquarium approaches a completed version ready to launch, digital copies will be distributed to a selected group so they can play the game for 2-3 weeks for further feedback and hence quality assurance. It would also be interesting to see, in light of research, if the Diaquarium provided knowledge to its users regarding self-treatment skills, and kept players within the game so that they could complete it as intended.

The Diaquarium has proven to be a game of great potential with a lot of opportunities regarding game objects, its features, possible rewards, and the convenience to distribute self-treatment skills to children living with Type 1 Diabetes Mellitus, and hopefully help them live a healthy life throughout. There is addressed some future work in this sub-chapter that can eventually contribute to launching the game one day.

Appendices

Appendix A

Diaquarium

Heisann!

Mitt navn er Ida Charlotte. Jeg er 25 år og studerer Informatikk ved Universitetet i Tromsø. Akkurat nå utvikler jeg et spill som heter Diaquarium (et akvarium hvor alle fisker har diabetes), og jeg trenger din hjelp! Kanskje har du allerede sett den lille filmsnutten jeg har laget? Da så du kanskje også at målet i spillet er å passe på at alle gullfiskene som bor der har det bra til enhver tid. En gullfisk som har diabetes må nemlig spise riktig mat og få riktig medisin for å trives. Først ønsker jeg at du skal se litt på noen bilder som viser hvordan spillet fungerer før du svarer på spørsmålene. Din mening er kjempeviktig, og kanskje kan du være med på å gjøre spillet enda bedre!

Med vennlig hilsen, Ida Charlotte

Gullfiskene i spillet har en helselinje som viser hvordan fisken har det akkurat nå. Målet er å holde pilen innenfor grønt område.
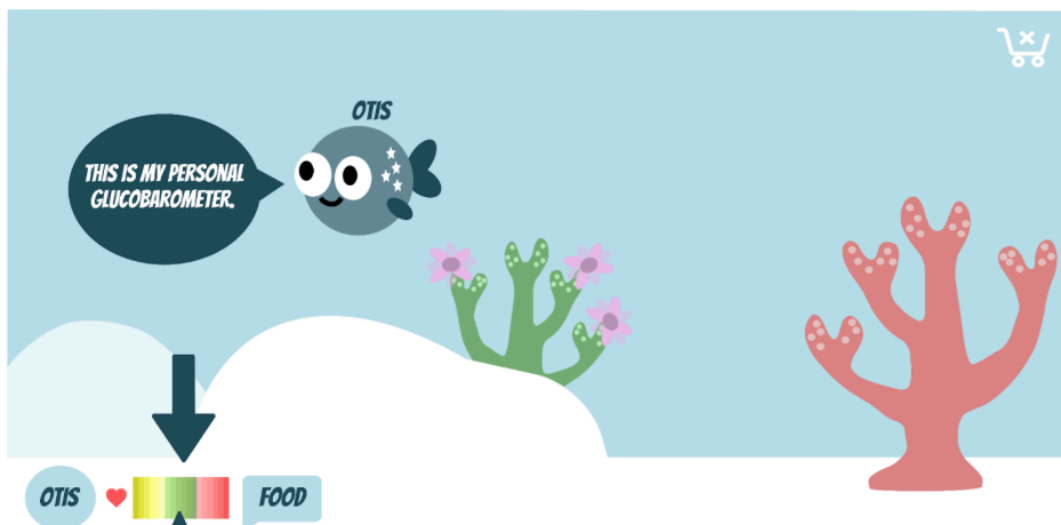
Hvis pilen er innenfor grønt område på helselinjen vil gullfisken skifte humør til det første bildet. Hvis pilen er innenfor gult område på helselinjen vil gullfisken skifte humør til bildet i midten. Hvis pilen er innenfor rødt område på helselinjen vil gullfisken skifte humør til bildet til høyre.
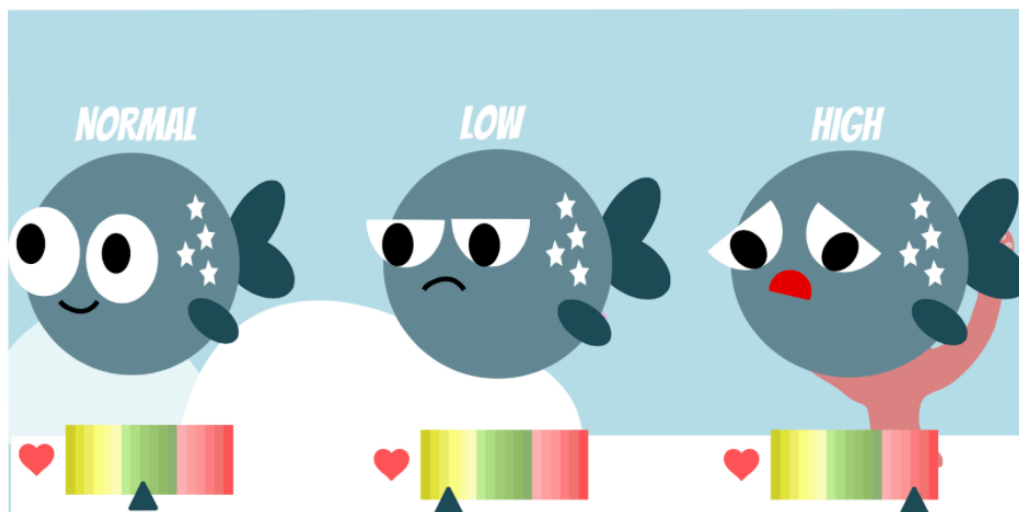
For å gi gullfiskene mat må man klikke på knappen hvor det står "food" (det engelske ordet for mat).
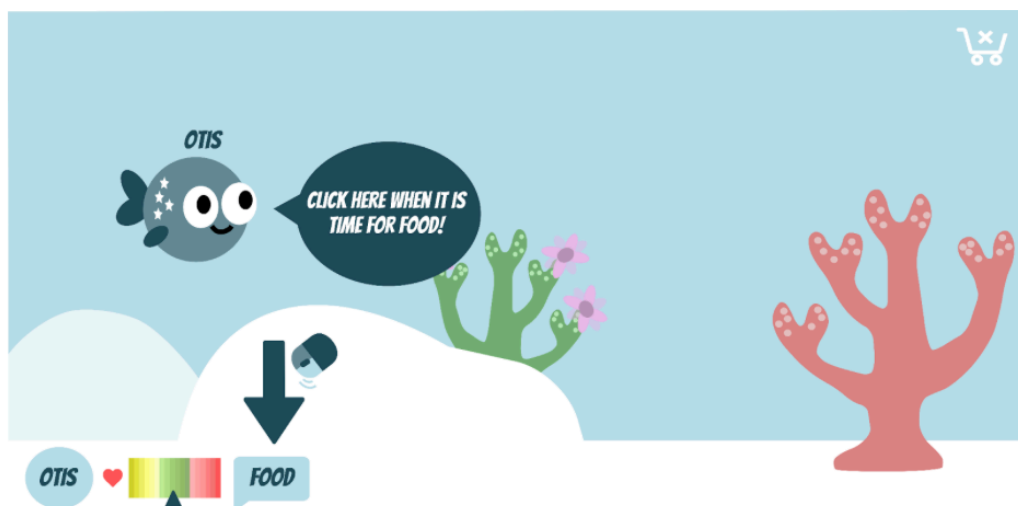
For å gi gullfiskene mat må man klikke på knappen hvor det står "food" (det engelske ordet for mat).
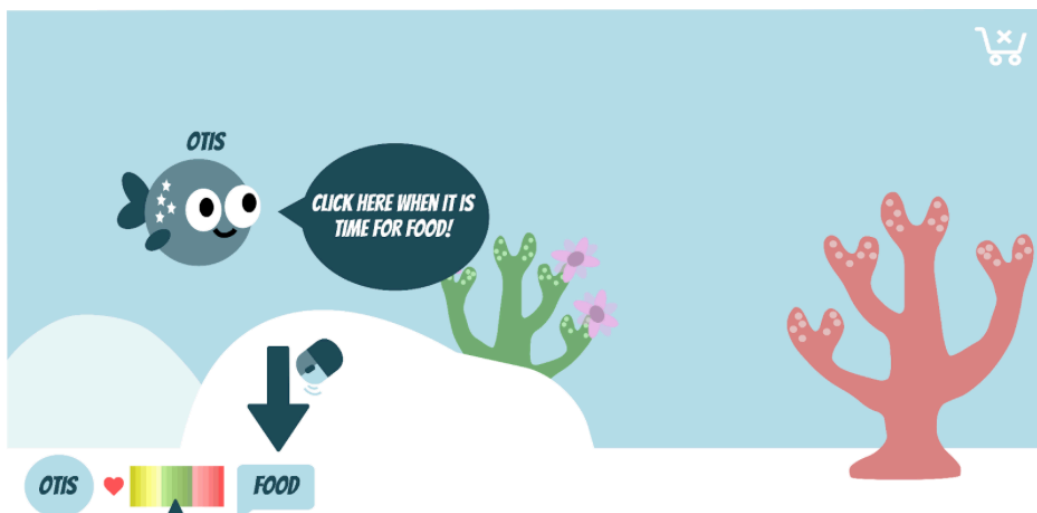
For å lage et måltid må du dra 3 ulike matvarer til et tallerken. Deretter må du velge hvor mye insulin (medisin) gullfisken skal få.
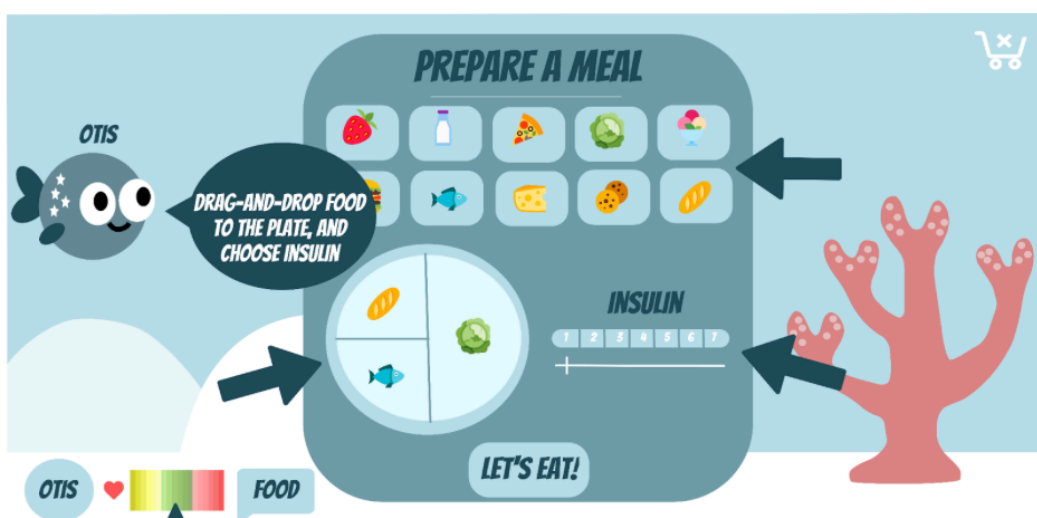
Her kan du se at gullfisken er i gul sone på helselinjen sin. Han ser ikke spesielt fornøyd ut, vi må gjøre noe med det!
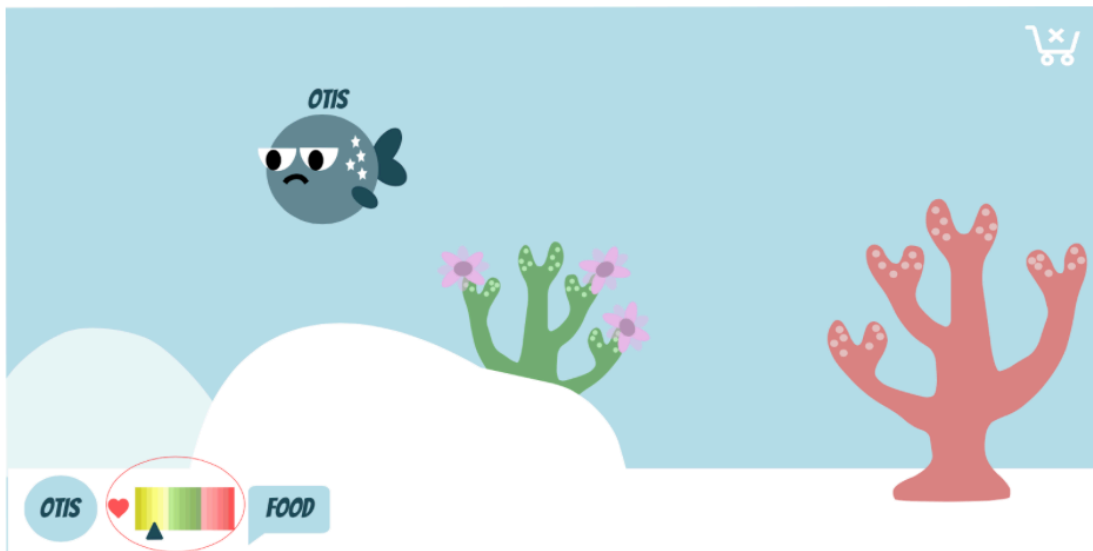
Her kan du se at gullfisken har fått mat og er nå i grønn sone på helselinjen sin. Han ser riktig så fornøyd ut!
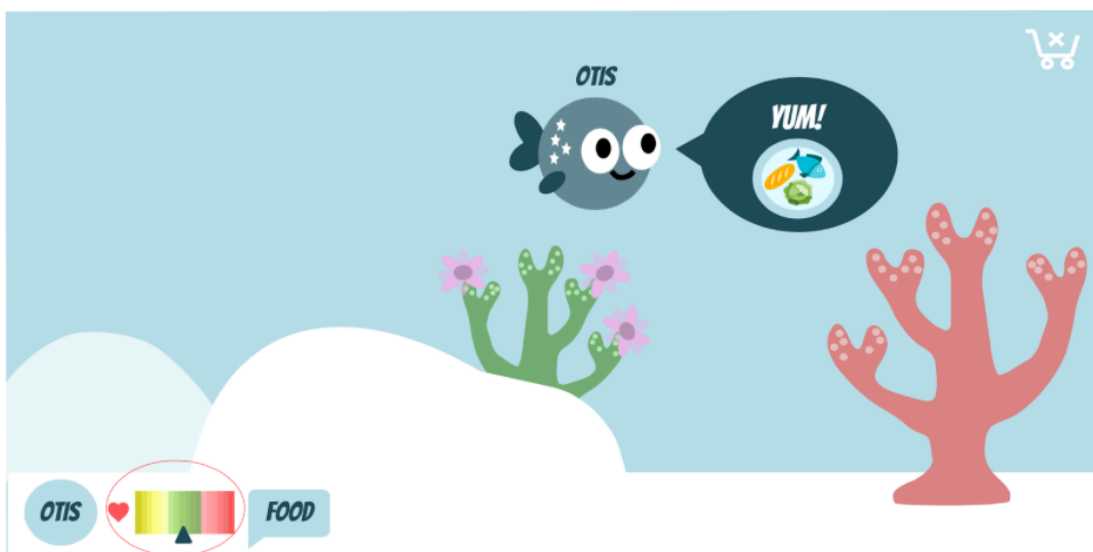
Ved å klikke på butikk-ikonet kommer du til gullfiskbutikken
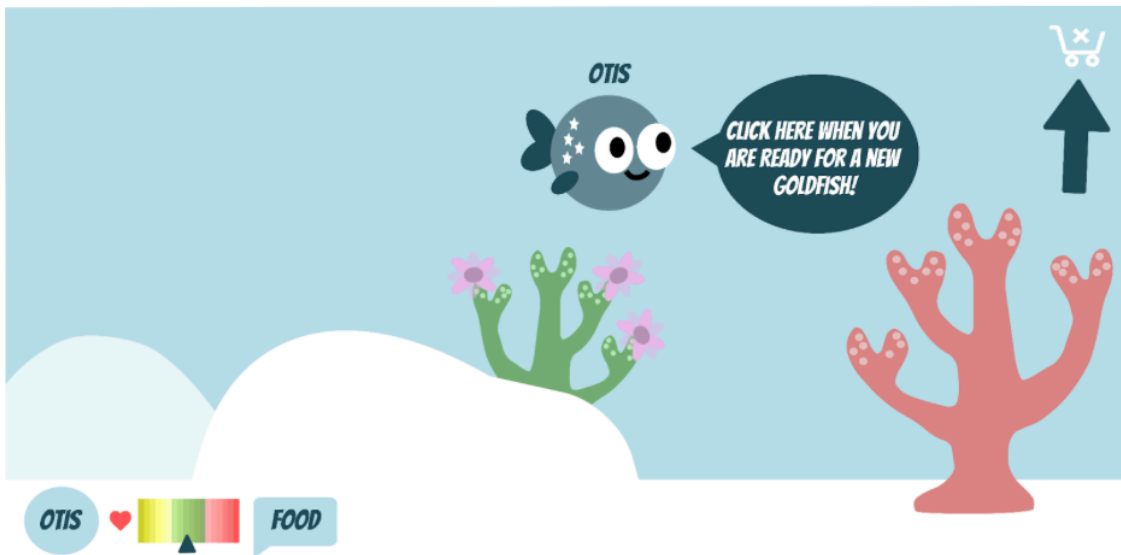
I gullfiskbutikken kan du kjøpe forskjellige gullfisker til akvariumet og gi de egne navn.

Plutselig er hele akvariumet fylt med gullfisker du må passe på!
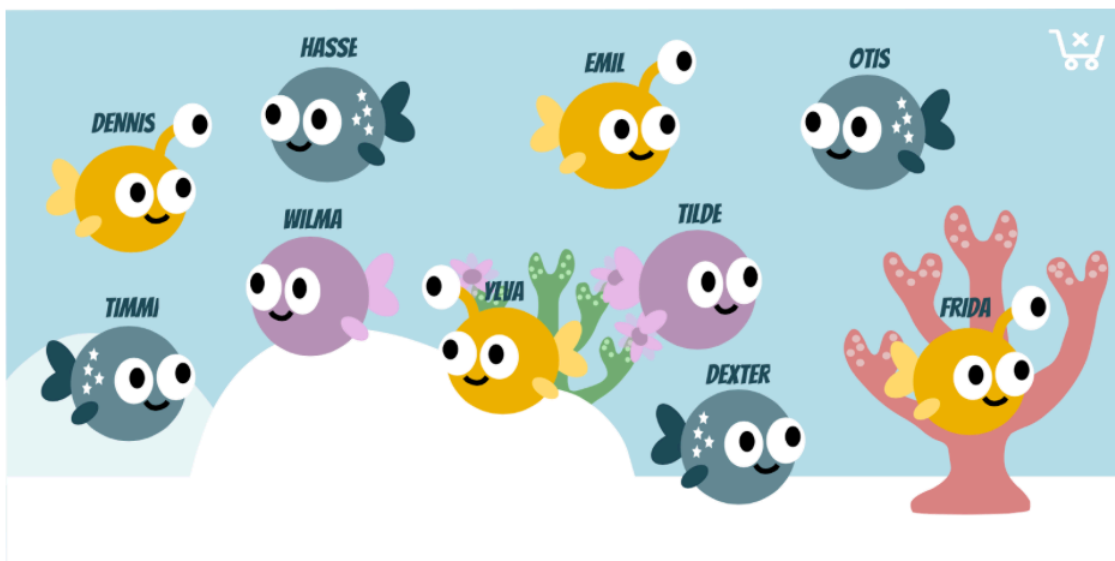
Når gullfisken din er klar til å reise til sitt nye forevige hjem dukker det opp en ny knapp
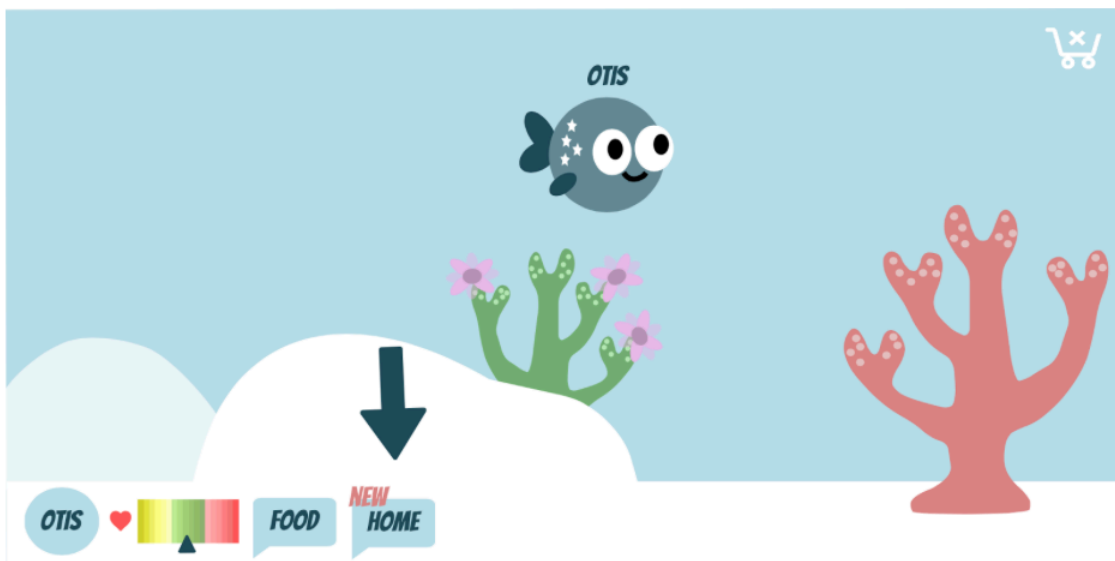
Når gullfisken din er klar til å reise til sitt nye forevige hjem dukker det opp en ny knapp
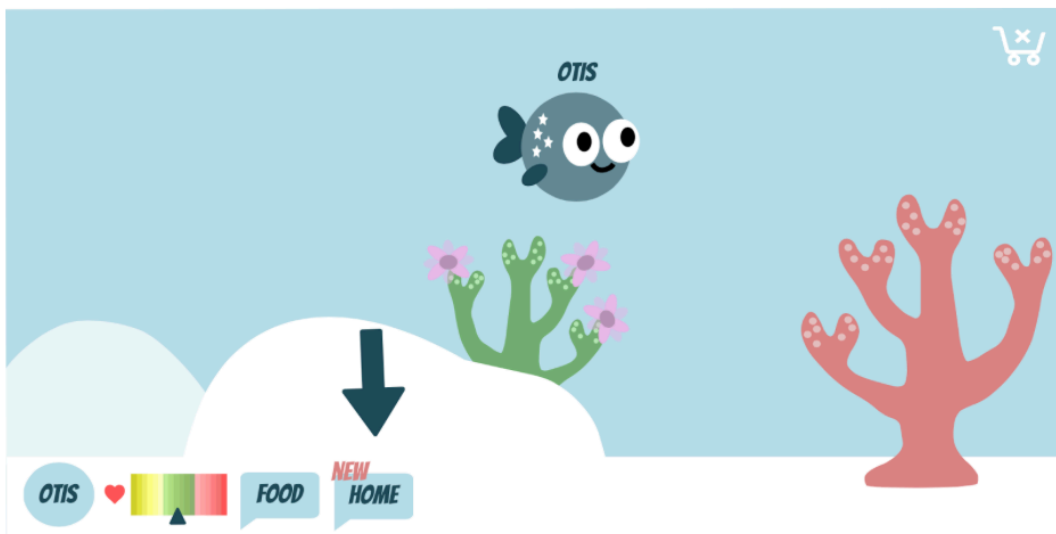
Ved å trykke på den nye knappen vil du se et nytt vindu hvor gullfisken sier han er klar til å flytte til sitt nye hjem. Ved å trykke OK vil han flytte dit.

Hvis gullfisken oppholder seg veldig lenge i enten gult eller rødt område på helselinjen blir gullfisken veldig syk og må flytte til sykehuset
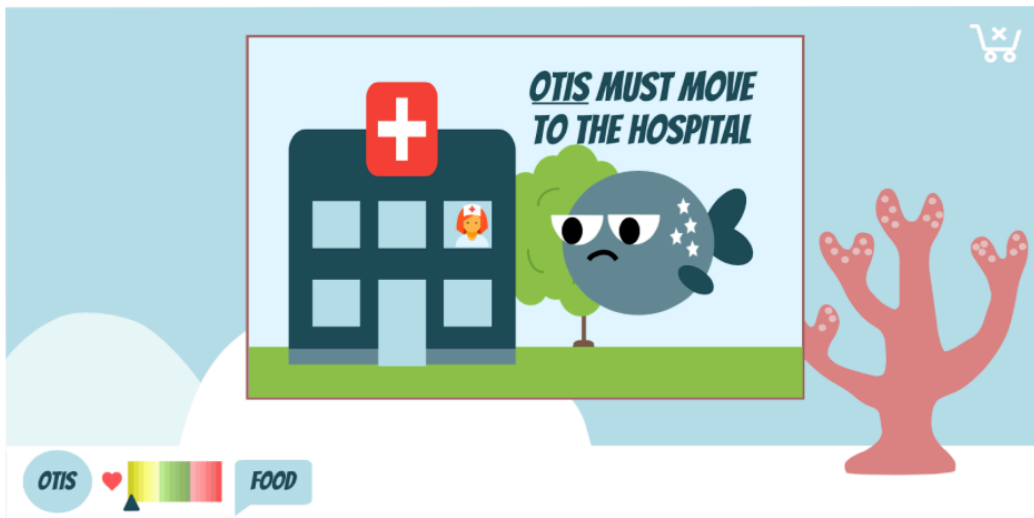
La oss sette i gang med spørsmålene!

1. **Er du gutt eller jente?**
   Merk av for alt som passer

   ☐ Gutt

   ☐ Jente

2. **Liker du gullfisker?**
   Markér bare én oval.

   ◯ Ja

   ◯ Nei

   ◯ Litt

3. **Liker du å spille spill?**
   Markér bare én oval.

   ◯ Ja

   ◯ Nei

   ◯ Litt

4. **Hva pleier du å spille på? (Du kan krysse av for flere svar)**
   Markér bare én oval.

   ◯ iPad

   ◯ PC

   ◯ Mobil

   ◯ Xbox

   ◯ Playstation

   ◯ Wii

   ◯ Annet

   ◯ Jeg liker ikke å spille

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Nå skal vi se litt på forskjellige typer belønninger i spillet, er du klar?

A DU ER KJEMPEFLINK!	**B** +1
C +100	**D** +3 MIN
E	**F** +1
G ???	**H** 100 XP

5. **Du får belønning hvis du gir riktig mat og medisin til gullfisken. Hvilken belønning liker du best? (Du kan krysse av for flere svar)**

Markér bare én oval.

- A) Ord som sier at jeg er flink
- B) Medaljer jeg kan vise til andre
- C) Gullmynter jeg kan kjøpe nye gullfisker med
- D) Medisinkoffert som holder gullfisken frisk i 3 minutter
- E) Musikk
- F) En gratis gullfisk
- G) En overraskelse
- H) Poeng til en high-score liste

6. **Hvis du MÅ velge 1 belønning, hvilken belønning liker du best?**
Markér bare én oval.

- ( ) A) Ord som sier at jeg er flink
- ( ) B) Medaljer jeg kan vise til andre
- ( ) C) Gullmynter jeg kan kjøpe nye gullfisker med
- ( ) D) Medisinkoffert som holder gullfisken frisk i 3 minutter
- ( ) E) Musikk
- ( ) F) En gratis gullfisk
- ( ) G) En overraskelse
- ( ) H) Poeng til en high-score liste

7. **Hvilke belønninger liker du minst? (Du kan krysse av for flere svar)**
   Markér bare én oval.

   - ◯ A) Ord som sier at jeg er flink
   - ◯ B) Medaljer jeg kan vise til andre
   - ◯ C) Gullmynter jeg kan kjøpe nye gullfisker med
   - ◯ D) Medisinkoffert som holder gullfisken frisk i 3 minutter
   - ◯ E) Musikk
   - ◯ F) En gratis gullfisk
   - ◯ G) En overraskelse
   - ◯ H) Poeng til en high-score liste

8. **Kan du tenke deg andre belønninger i spill som du liker?**

   ....
   ....
   ....
   ....
   ....

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Nå skal vi se litt på forskjellige måter du kan få belønning på, er du klar?
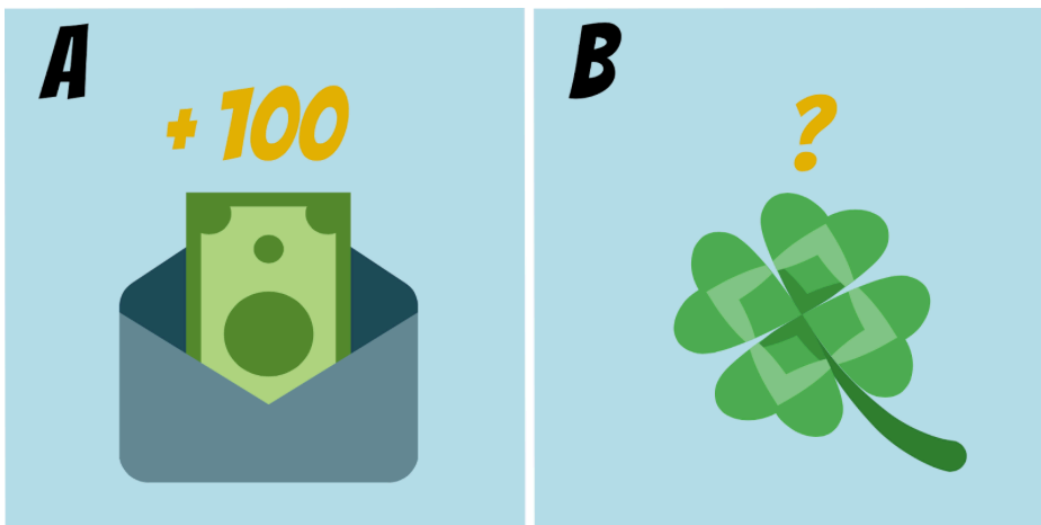
9. **Hvis en gullfisk flytter til et nytt hjem får du gullmynter. Ønsker du en fast pris som betaling, eller vil du prøve lykken og se hvilken betaling du får?**
   Markér bare én oval.

   ⬭ A) Fast pris

   ⬭ B) Prøve lykken
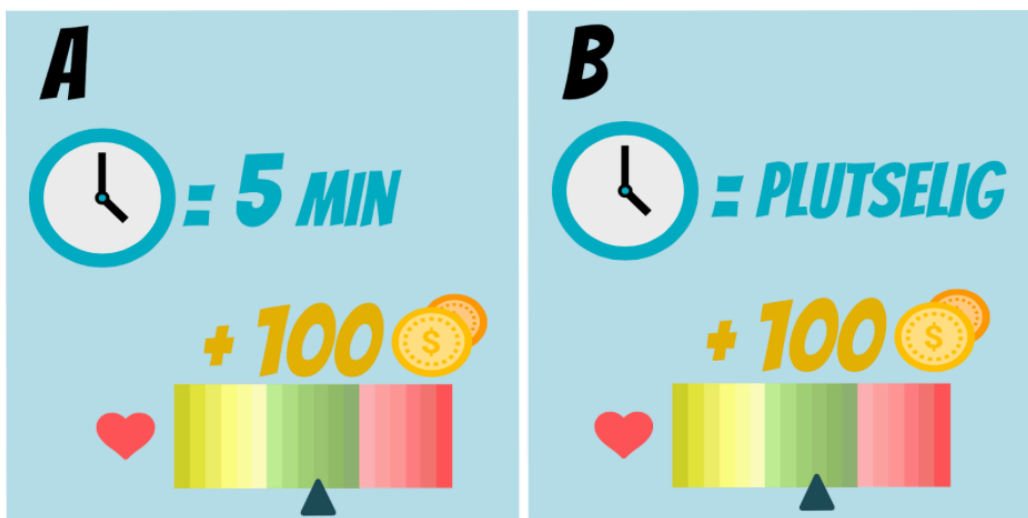
10. **Hvis du holder deg innenfor grønt område blir du belønnet med for eksempel gullpenger. Når ønsker du at belønningen skal komme?**
    Markér bare én oval.

    ⬭ A) Etter hvert 5 minutt i grønn sone
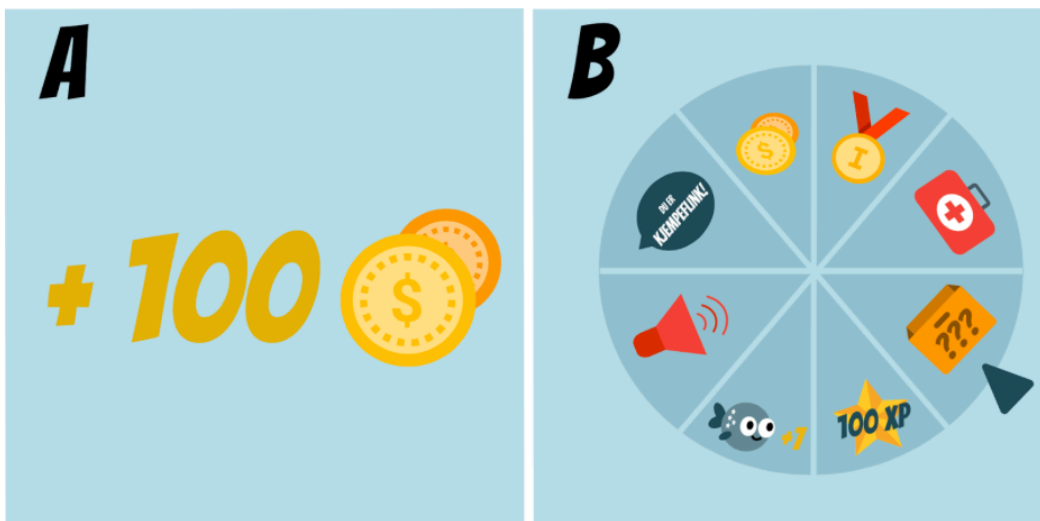
    ⬭ B) Plutselig!

11. **Hvis du klarer å lage 3 riktige måltider på rad får du belønning. Hvordan vil du få belønningen?**

    Markér bare én oval.

    ( ) A) En fast belønning hver gang, som for eksempel 100 gullmynter

    ( ) B) Snurre lykkehjulet og se hvilken belønning jeg får

12. **Har du lyst på en gratis belønning med en gang du starter spillet?**

    Markér bare én oval.

    ( ) Ja, det hadde vært gøy!

    ( ) Nei, jeg har bare lyst til å spille med en gang
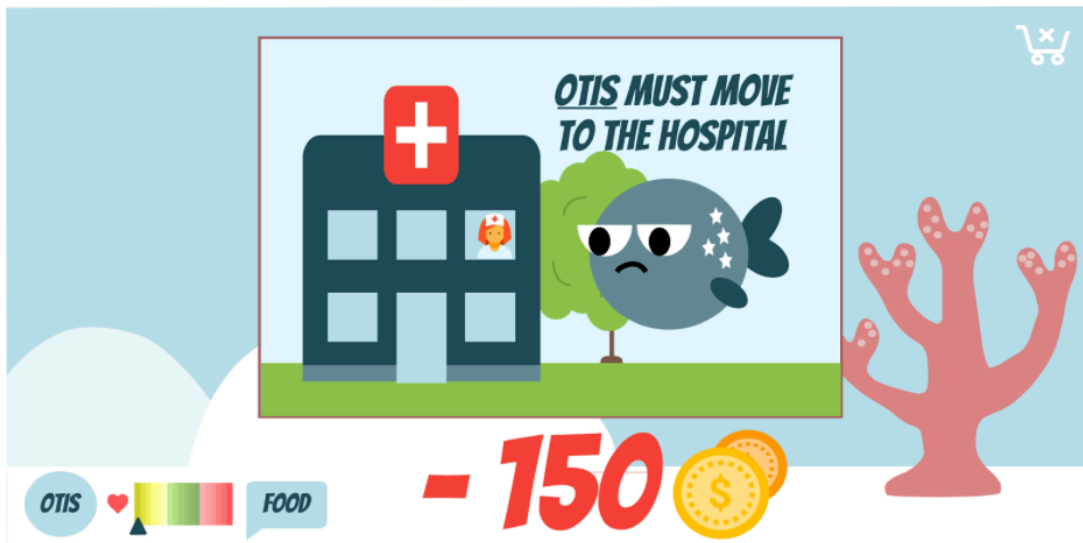
13. **Hvis gullfisken må flytte til sykehuset må du betale for oppholdet i gullmynter. Hva tenker du om det?**

Markér bare én oval.

◯ Det er i orden, da skal jeg passe godt på de andre gullfiskene

◯ Det er ikke i orden, da vil jeg ikke spille mer
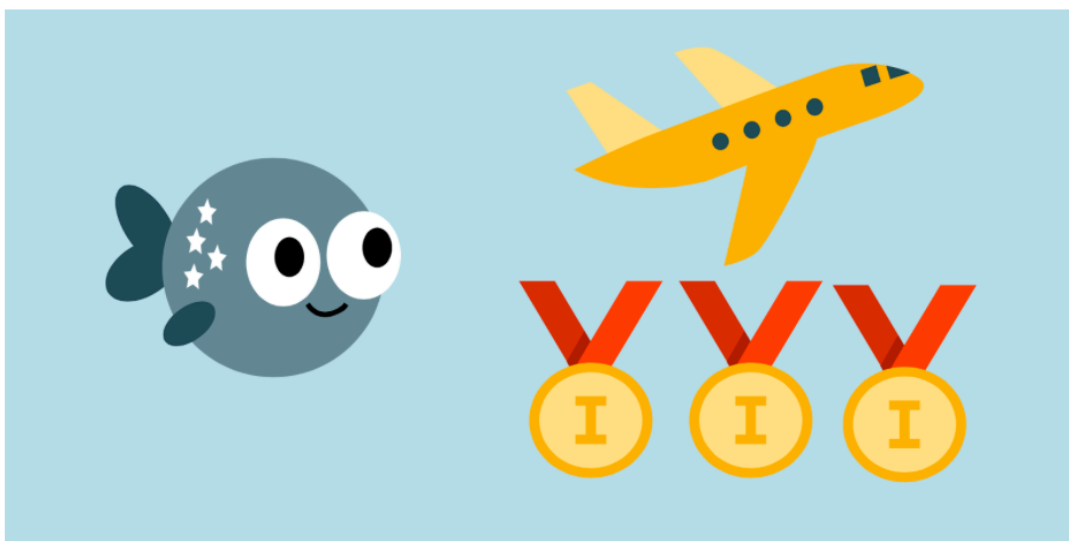
14. **Hvis du har samlet nok belønning (for eksempel medaljer) kan du fly til andre akvarium og chatte med gullfiskene der. Hva tenker du om det?**

Markér bare én oval.

◯ Det høres kult ut!

◯ Nei, jeg liker ikke å chatte med andre

Nå vil du få noen spørsmål om hva du synes om spillet mitt, er du klar?

15. **Hva synes du om spillet?**
    Markér bare én oval.

    ◯ Jeg liker det veldig godt

    ◯ Jeg synes det er OK

    ◯ Jeg liker det ikke

16. **Kan du tenke deg å prøve spillet en dag?**
    Markér bare én oval.

    ◯ Ja

    ◯ Nei

    ◯ Kanskje

17. **Hva synes du om fargene i spillet?**
    Markér bare én oval.

    ◯ Jeg liker fargene veldig godt

    ◯ Jeg synes fargene er OK

    ◯ Jeg liker ikke fargene

18. **Hva synes du om at spillet foregår i et akvarium?**
    Markér bare én oval.

    ◯ Jeg liker det veldig godt

    ◯ Jeg synes det er OK

    ◯ Jeg liker det ikke

19. **Liker du at karakterene i spillet er fisker?**
    Markér bare én oval.

    ◯ Jeg liker det veldig godt

    ◯ Jeg synes det er OK

    ◯ Jeg liker det ikke

20. **Hva synes du om bildene i spillet?**
    Markér bare én oval.

    ◯ Jeg liker de veldig godt

    ◯ Jeg synes de er OK

    ◯ Jeg liker de ikke

21. **Synes du spillet ser vanskelig ut?**
Markér bare én oval.

◯ Ja

◯ Nei

◯ Litt

22. **Var det vanskelig å forstå hva spillet går ut på?**
Markér bare én oval.

◯ Ja

◯ Nei

◯ Litt

23. **Var det vanskelig å forstå hvordan man får belønning i spillet?**
Markér bare én oval.

◯ Ja

◯ Nei

◯ Litt

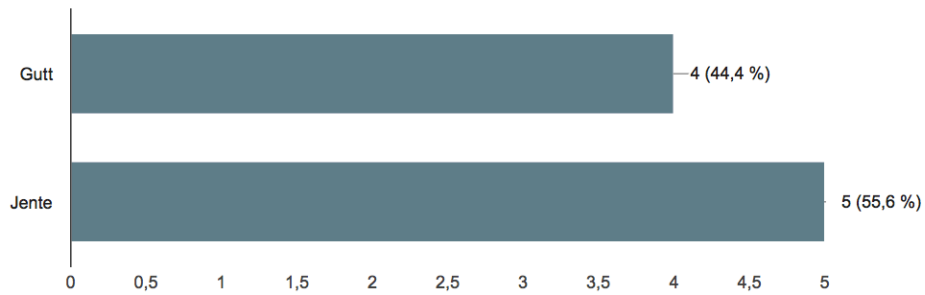24. **Har du forslag til andre ting jeg kan ha med i spillet?**

....

....

....

....

....

Tusen takk for at du tok deg tiden til å svare på spørsmålene mine. Med din hjelp kan jeg gjøre spillet enda bedre!

Appendix B

Er du gutt eller jente? (9 svar)

Liker du gullfisker? (9 svar)

- Ja
- Nei
- Litt

Liker du å spille spill? (9 svar)

- Ja
- Nei
- Litt

Hva pleier du å spille på? (Du kan krysse av for flere svar) (9 svar)

- iPad
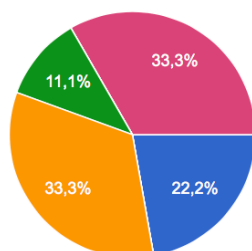- PC
- Mobil
- Xbox
- Playstation
- Wii
- Annet
- Jeg liker ikke å spille

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Du får belønning hvis du gir riktig mat og medisin til gullfisken. Hvilken belønning liker du best? (Du kan krysse av for flere svar)
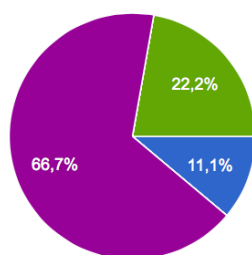(9 svar)
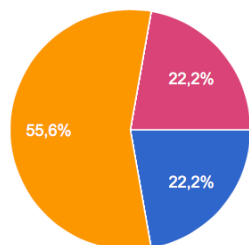
- ● A) Ord som sier at jeg er flink
- ● B) Medaljer jeg kan vise til andre
- ● C) Gullmynter jeg kan kjøpe nye gullfisker med
- ● D) Medisinkoffert som holder gullfisken frisk i 3 minutter
- ● E) Musikk
- ● F) En gratis gullfisk
- ● G) En overraskelse
- ● H) Poeng til en high-score liste

Hvis du MÅ velge 1 belønning, hvilken belønning liker du best? (9 svar)

- ● A) Ord som sier at jeg er flink
- ● B) Medaljer jeg kan vise til andre
- ● C) Gullmynter jeg kan kjøpe nye gullfisker med
- ● D) Medisinkoffert som holder gullfisken frisk i 3 minutter
- ● E) Musikk
- ● F) En gratis gullfisk
- ● G) En overraskelse
- ● H) Poeng til en high-score liste

Hvilke belønninger liker du minst? (Du kan krysse av for flere svar) (9 svar)

- ● A) Ord som sier at jeg er flink
- ● B) Medaljer jeg kan vise til andre
- ● C) Gullmynter jeg kan kjøpe nye gullfisker med
- ● D) Medisinkoffert som holder gullfisken frisk i 3 minutter
- ● E) Musikk
- ● F) En gratis gullfisk
- ● G) En overraskelse
- ● H) Poeng til en high-score liste

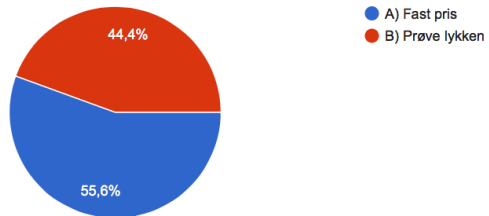## Kan du tenke deg andre belønninger i spill som du liker? (2 svar)

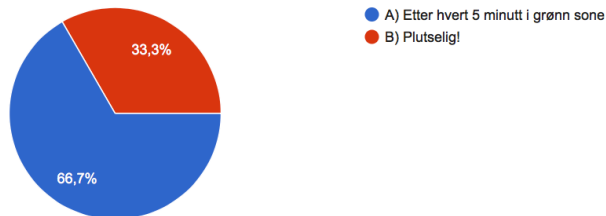| |
|---|
| nei |
| en spesial fisk. |

170

Hvis en gullfisk flytter til et nytt hjem får du gullmynter. Ønsker du en fast pris som betaling, eller vil du prøve lykken og se hvilken betaling du får?
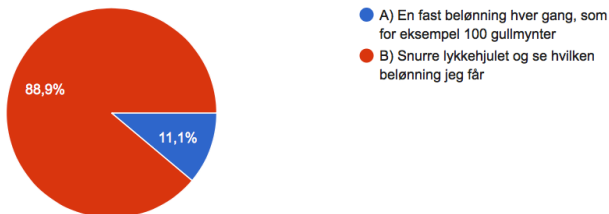(9 svar)

- A) Fast pris
- B) Prøve lykken

44,4%

55,6%

Hvis du holder deg innenfor grønt område blir du belønnet med for eksempel gullpenger. Når ønsker du at belønningen skal komme?
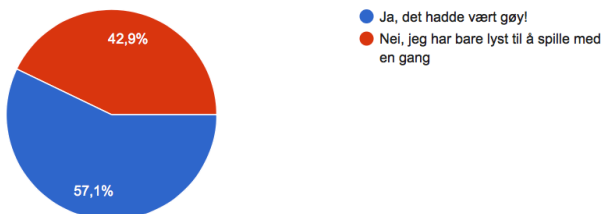(9 svar)

- A) Etter hvert 5 minutt i grønn sone
- B) Plutselig!

33,3%

66,7%

Hvis du klarer å lage 3 riktige måltider på rad får du belønning. Hvordan vil du få belønningen?
(9 svar)

- A) En fast belønning hver gang, som for eksempel 100 gullmynter
- B) Snurre lykkehjulet og se hvilken belønning jeg får

88,9%

11,1%

Har du lyst på en gratis belønning med en gang du starter spillet? (7 svar)

- Ja, det hadde vært gøy!
- Nei, jeg har bare lyst til å spille med en gang

42,9%

57,1%

171

Hvis gullfisken må flytte til sykehuset må du betale for oppholdet i gullmynter. Hva tenker du om det?
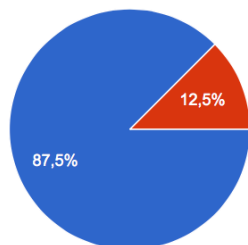(8 svar)

- Det er i orden, da skal jeg passe godt på de andre gullfiskene
- Det er ikke i orden, da vil jeg ikke spille mer

100%

Hvis du har samlet nok belønning (for eksempel medaljer) kan du fly til andre akvarium og chatte med gullfiskene der. Hva tenker du om det?
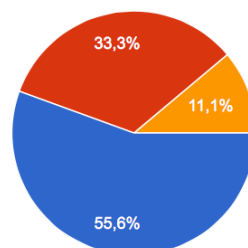(8 svar)

- Det høres kult ut!
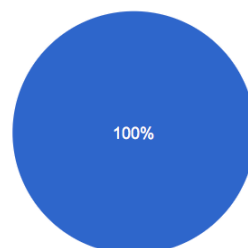- Nei, jeg liker ikke å chatte med andre

87,5% 12,5%

Nå vil du få noen spørsmål om hva du synes om spillet mitt, er du klar?
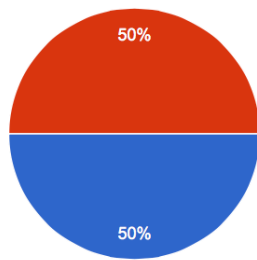
Hva synes du om spillet? (9 svar)

- Jeg liker det veldig godt
- Jeg synes det er OK
- Jeg liker det ikke

33,3% 11,1% 55,6%

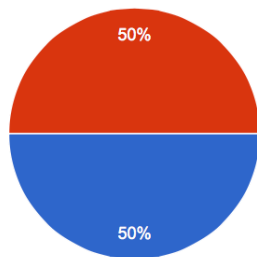## Kan du tenke deg å prøve spillet en dag? (8 svar)

- Ja
- Nei
- Kanskje

100%

172

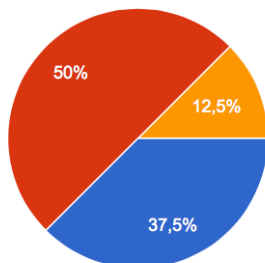## Hva synes du om fargene i spillet? (8 svar)

- Jeg liker fargene veldig godt
- Jeg synes fargene er OK
- Jeg liker ikke fargene

50%

50%

Hva synes du om at spillet foregår i et akvarium? (8 svar)
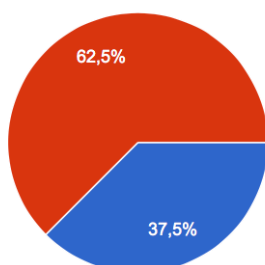

- Jeg liker det veldig godt
- Jeg synes det er OK
- Jeg liker det ikke

50%

50%

Liker du at karakterene i spillet er fisker? (8 svar)
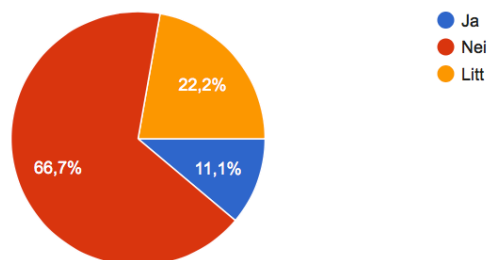

- Jeg liker det veldig godt
- Jeg synes det er OK
- Jeg liker det ikke

50%

12,5%

37,5%

Hva synes du om bildene i spillet? (8 svar)

- Jeg liker de veldig godt
- Jeg synes de er OK
- Jeg liker de ikke

62,5%

37,5%

Synes du spillet ser vanskelig ut? (9 svar)

- Ja
- Nei
- Litt

22,2%
66,7%
11,1%

Var det vanskelig å forstå hva spillet går ut på? (9 svar)

- Ja
- Nei
- Litt

33,3%
66,7%

Var det vanskelig å forstå hvordan man får belønning i spillet? (8 svar)

- Ja
- Nei
- Litt

37,5%
12,5%
50%
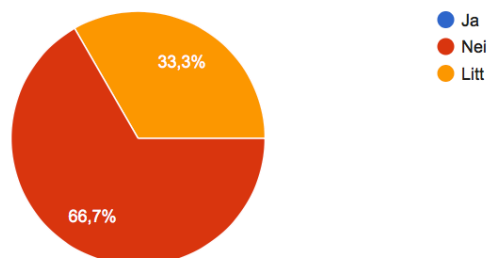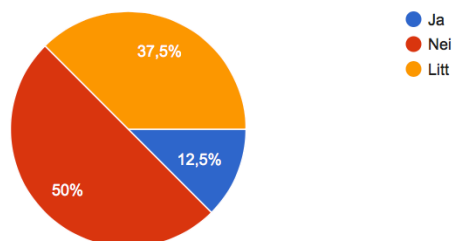
Har du forslag til andre ting jeg kan ha med i spillet? (4 svar)

nei
katt
Karakterene kan være mensker.
litt flere andre fisker

174

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